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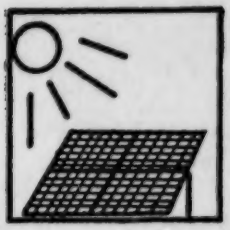
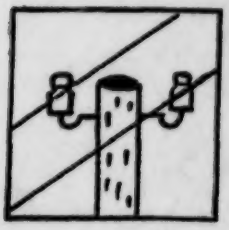
FOR AFRICA

EXISTING RURAL TELECOMMUNICATIONS SYSTEMS IN AFRICA





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ABBREVIATIONS

ADB	African Development Bank
CES	Central Earth Station
DAMA	Demand Assignment Multiple Access
DC	Digital Concentrator
ECA	Economic Commission for Africa
EDF	European Development Fund
ES	Earth Station
IDA	International Development Association
MAR	Multi-Access Radiotelephone
PCM	Pulse Code Modulation
PCO	Public Call Office
RSU	Remote Switching Unit
SCPC	Single-Channel Per Carrier
SEC	Small Exchange Configuration
SSB	Single Side Band
TDMA	Time Division Multi-Access
UHF	Ultra High Frequency
UNTACDA	United Nations Transport and Communications Decade for Africa
VHF	Very High Frequency

FOREWORD

Given the rural character of the African continent, the development of rural telecommunications is one of the prerequisites for improving the living-conditions of its population. It is generally accepted that social and economic development are cross-referenced with the implementation and expansion of telecommunication services.

Fortunately, in this particular domain, modern telecommunications technology has produced a large scope of possibilities in such a way that technical solutions are within the means of the administrations concerned to solve nearly any technical problem with regard to connecting remote areas to the national telecommunication networks.

In general telecommunications as a whole are profitable, but extending telecommunications services to the rural areas at first sight do not seem to be economically viable when viewed from the point of profitability alone; indirect benefits have to be taken into account.

It is recognized that the volume of traffic in and out of the rural areas is low and the revenues generated by their services are mostly in local currency. Yet the equipment has to be bought in foreign currency. These are special difficulties that the African governments would need to address. Hence different and more flexible policies are required to meet the demand in rural areas.

One possible solution of achieving lower investment costs is by placing grouped orders of equipment, local manufacturing and the use of less sophisticated equipment. another important method to save scarce resources is to plan in advance instead of piece meal development.

The Economic Commission for Africa - by means of this publication - wants to disseminate the experiences that some African countries have so far made with rural telecommunications. It is supposed to provide guidelines to policy-makers and planners.

The ECA wishes to use this opportunity to express its gratitude to the Administrations from Burkina Faso, Cameroon, Ethiopia, Malawi, Mali, Niger, Togo and Zimbabwe who kindly accepted to contribute to this study by allowing fact-finding missions and by making available important data and information.

1. INTRODUCTION

1.1 Historical Background

Within the framework of the United Nations Transport and Communications Decade Programme for Africa (UNTACDA) the ECA has organized, in co-operation with the Federal Republic of Germany (FRG), four seminars on planning of rural telecommunications.

One basic seminar and one follow-up seminar were held in 1984 in Addis Ababa and 1987 in Harare respectively, for senior planners and economists from English-speaking African countries. Two seminars of the same profile were organized for French-speaking and Lusophone countries 1985 in Lome and 1988 in Yaounde.

The follow-up seminars were based on case studies and showed concrete planning strategies including technical and economic aspects, the preparation of projects and their presentation in bankable format. The seminars were well accepted by the participants and especially their practical orientation was highly appreciated.

In addition to the above seminars, ECA provided advisory services on the development of rural telecommunications, on request, to various member States. The purpose of the missions was to prepare comprehensive reports on the introduction of rural telecommunications in the respective national telecommunication networks. The reports were presented in a way that they might be submitted to lending agencies and bilateral donors for potential financing of the project or parts thereof.

1.2 Establishment of a Rural Telecommunications Pilot Project for Africa

Having covered the aspects of training and planning for the implementation of rural telecommunications, it is felt that the performances of available systems with regard to appropriate rural technology as well as the economic benefits should be demonstrated by a rural telecommunications pilot project for Africa. The main objective of the proposed project which will go beyond theory is to show the importance of telecommunication services to those countries in which governments failed to recognize it as such.

However, quite a number of African countries have already extended services to the rural areas, utilizing conventional and modern telecommunication systems. The experience gained in this field will be very useful for the concept of the pilot project. It also constitutes the main substance of the study since it is considered to be a preparatory step for the envisaged project.

2. IMPORTANCE OF RURAL TELECOMMUNICATIONS

In most African countries, there are two critical and interrelated trends effecting their national well-being:

(i) Rural population tends to be drawn into cities in search of economic opportunity;

(ii) The influx of rural population into cities triggers unemployment and problems of urban decay.

One effective means of steeming the tide is to bring economic opportunity into the country-side. This in turn implies developing the necessary economic infrastructure for the rural development, telecommunications being one of the most critical aspects of this infrastructure.

When developing or creating centers in rural areas, communication facilities have to be made available. It is important to realize that telecommunication services are beneficial to government projects and raise the welfare of the rural people and the nation as a whole.

Many studies have already been conducted outside Africa that have demonstrated definite correlation between telecommunications and economic development, including the direct and indirect benefits from these services. The studies have also proved that rural telecommunication services are mainly used in connection with economic production and distribution and they exhibit high rates of economic return. Since these services are part of the basic infrastructure for the promotion of economic development, they are essential for the improvement of the living conditions for the rural population in Africa.

3. AVAILABLE SYSTEMS FOR SERVICE OF RURAL AREAS

3.1 Requirements

By extending telecommunications to the rural areas it is understood, that the subscriber stations are fully automatic and that they are connected to the national network like any subscriber in urban areas. Consequently, the area code and subscriber numbers are part of the national number plan. Charging is also possible according to the existing charging plan.

As for the number of stations required in rural areas, there are several objectives to be met which are cross-referenced:

- the average penetration of the telephone within the whole country should have been at least one line per 100 inhabitants by end of 1988, as per the objectives of the "United Nations Transport and Communications Decade for Africa" (UNTACDA);

- for rural telecommunications, one public call office (PCO) is suggested for 10,000 inhabitants;

- the public call offices shall be distributed in a way that the majority of the grown-up population lives and/or works within a perimeter of five kilometers.

The method for the determination of the number of stations required depends on the data which are available.

3.2 Conventional technology

In conventional technology, subscriber access to exchanges is usually ensured by the following analogue systems:

- open wire lines (single subscriber or 1 + 1)
- aerial cables
- buried cables
- open wire lines with subscriber carrier systems.

The investment costs depend on the distances and the number of pairs (channels) conducted in the respective system. In addition to this the prices vary considerably from country to country, thus amounting to about $US 1,200 per pair/km for poles with only one copper-clad pair, if the line is to be built.

If, for instance, the pole carries 10 pairs, the cost of one pair/km is about $US 600. The costs per pair/km in aerial and buried cables with a capacity of 10 pairs vary between $US 200 and 300.

Annual charges for maintenance of pole lines with open wire are considerable and may amount to 11 per cent of the investment. The comparative costs for pole lines with aerial cables and for buried cables are five per cent and one per cent respectively. In certain cases, pole

lines with open wire provide a very low quality of service.

As for the exchanges in rural areas, there exist small analogue centres, but many are manual, the access to their respective transit exchange being operated on either manual or semi-automatic circuits. Investment costs for small manual exchanges are comparatively low (about $US 6,500 for 10-50 stations). But these exchanges very often operate only during fixed office hours and occasionally subscribers complain on absence of operators during offical working periods.

Transmission paths between rural exchanges and the respective transit centre very often use the same technology as described for subscriber access. Narrow-band microwave links are rarely installed in this environment.

The problems of energy supply in remote areas cannot be overstressed. In many regions, public electric energy is not provided at all or available only at certain time. In those cases, conventional systems are usually supplied by diesel generators. But for most of the modern system, designed for the rural environment can be fed by solar power. Hence the charges for power supply cannot be neglected when making economic comparisons.

A diesel generator for stand-by use only has a 20 years life-time period, whereas when being used continuously, the expected life-time is only 3-10 years. The annual charges for maintenance and operation in the case of stand-by application vary from 13 to 18 per cent and for continuous power application from 28-58 per cent of the investment costs.

3.3 Modern technology

In modern technology, subscriber access to exchanges can be provided by using the following systems:

- digital subscriber carrier
- single channel point to point radio links and group systems (Fig. 3.1)
- low capacity digital microwave links with concentrator (Figure 3.2)
- multi access radio-telephone systems with concentrator (MAR), (Figure 3.3)
- distributed concentrators with PCM connected via cables with multidrop capacity, also possible on optical fiber and UHF digital radio (Figure 3.4)
- radio call systems (SSB)
- small earth stations (SCPC) for satellite communications (Figure 3.5)

All of the above indicated systems have low energy consumption so that they can be powered by solar equipment. Unit prices for investment vary considerably and depend on the total number of subscribers to be connected and, within a cluster, of the individual subscribers' distance

to the concentration point. On the other hand, the distance is not important within the range of one transmission hop when using radio links, whereas in a rural satellite system it is completely irrelevant.

Given these facts, installation costs per subscriber, ready for service and including power supply, have a large spectrum and may go from $US 5,000 to $US 15,000. As a matter of fact, some systems become economically feasible only when having a minimum number of subscribers (e.g. fiber optic cables, rural satellite systems). Therefore, each scenario has to be calculated separately.

The annual charges for subscriber access systems on buried cables including fiber optics and radio systems are about 1-2 per cent of the investment costs excluding the radio call system having 10 per cent of charges for maintenance. However, for satellite earth stations, annual charges of 5 per cent of investment must be calculated for maintenance and 10 per cent for operation (renting of transponder).

As concerns switching in rural areas, the following techniques exist:

- digital concentrator (DC) respectively remote switching unit (RSU)

- small exchange configuration (also mobile)
- rural satellite system (DAMA operation) which includes switching (Figure 3.6)

Digital concentrators, also called "remote switching units" are the most economic equipment to be used for switching. However, they can only be introduced in connection with a host exchange containing the core unit by which they are controlled. An interruption of the microwave or cable links to the host exchange usually cuts normal operation of the concentrator, unless local traffic is ensured. Unit costs per subscriber lines may amount to $US 300 excluding the share cost of the core unit in the host exchange.

Small rural exchanges are autonomous thus having full independent call processing. Their unit price per subscriber may be at about $US 1,200, but they can be installed independently from any host exchange.

The rural satellite systems with demand assignment - multiple access (DAMA) include the switching. Hence when comparing costs with any terrestrial transmission configuration, the share cost for switching should be added to the latter.

The nature of transmission paths depends on the terrain. They may consist of narrow-band digital radio link (2 Mbit/s, 8 Mbit/s) or PCM on cables. If distances are more limited and the terrain is flat, PCM on cables may be more economical. Because of the remoteness of many rural areas and the low traffic generated, terrestrial long distance transmission facilities may be too expensive. In those cases advantage can be taken

from a rural satellite system, as transmission costs are independent of distance within the same coverage area.

The turnkey cost per relay station of digital microwave links of 2 Mbit/s with 30 channels (1+1) is estimated at $US 190,000, but under certain conditions mini-link stations (1+0) may be sufficient. they could be obtained from $US 45,000.

The rural equipment described within the part concerning modern technology have an energy consumption in the rage of 20-400 W, but in some cases, the overall power requirement may be up to 1,000 W. For an output of up to 400 W, power supply systems utilizing exclusively solar energy can be set up in many parts of the world with excellent overall cost-effectiveness. A combined solar-power/wind-turbine system can be advantageous, especially when the power requirement is higher and provided the right geographical location is given.

Presently, investment costs for solar and wind energy systems are still higher than for other energy forms, but the over-all annual charges (including depreciation) are considerably lower as there is no need for consumables. Besides the power consumption, investment costs depend on the availability of the energy sources (insolation, wind speed) and the method of conditioning the environment around the electronic equipment.

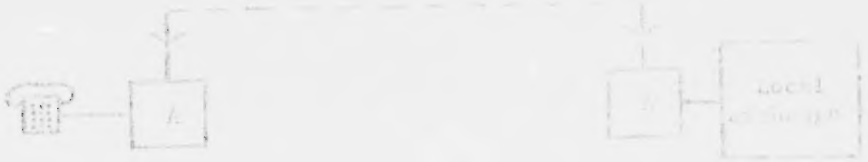


Figure 3.1. Single channel point to point radio link

Figure 3.2. An analog/digital subscriber loop telephone system

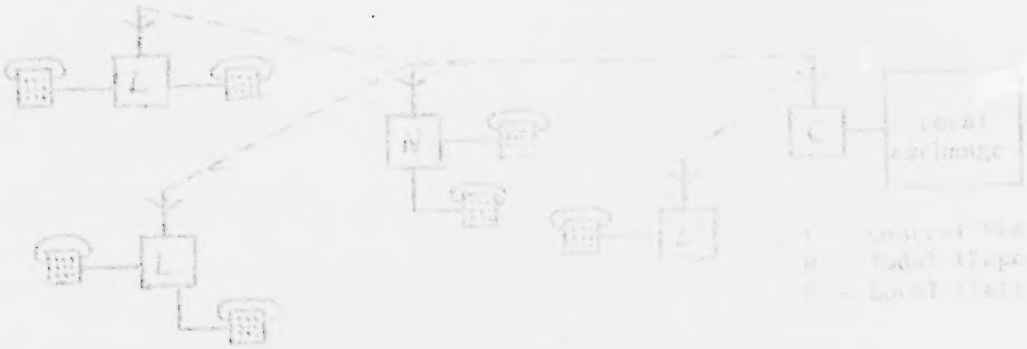


Figure 3.3. Multi access radio-telephone system

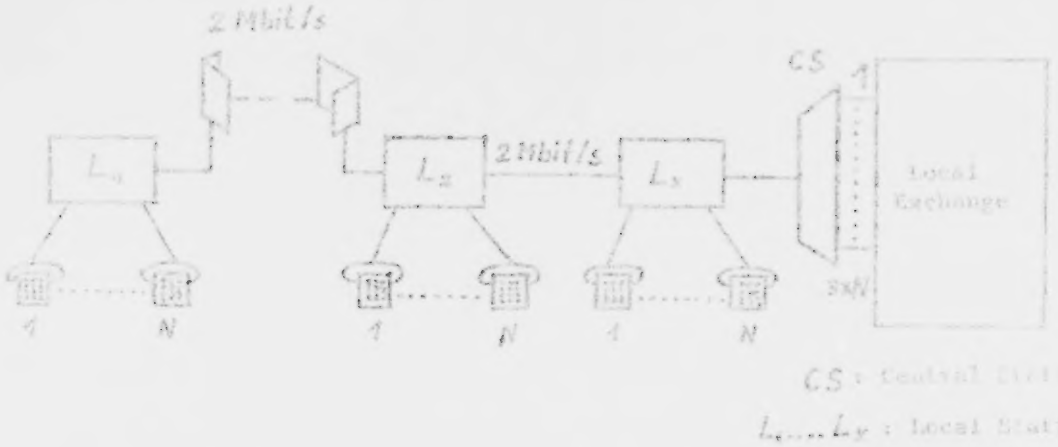


Figure 3.4. Distributed concentrator with PCM connected via a digital radio link (section A) and via cables (sections B and C)

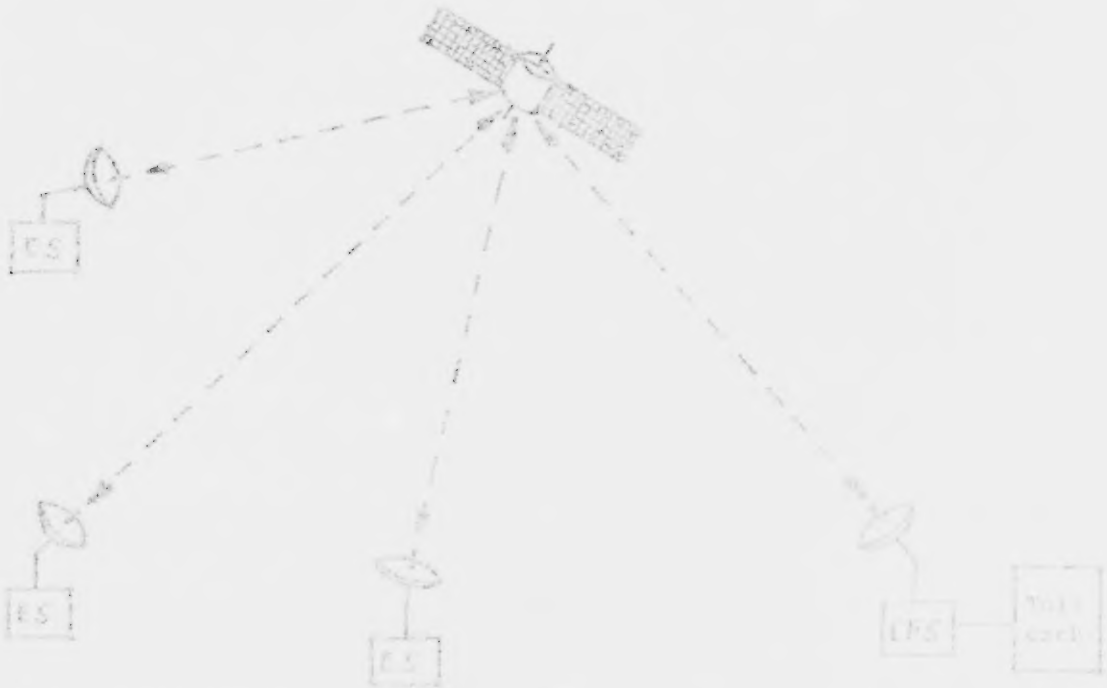


Figure 3.5. Rural earth stations for satellite communication

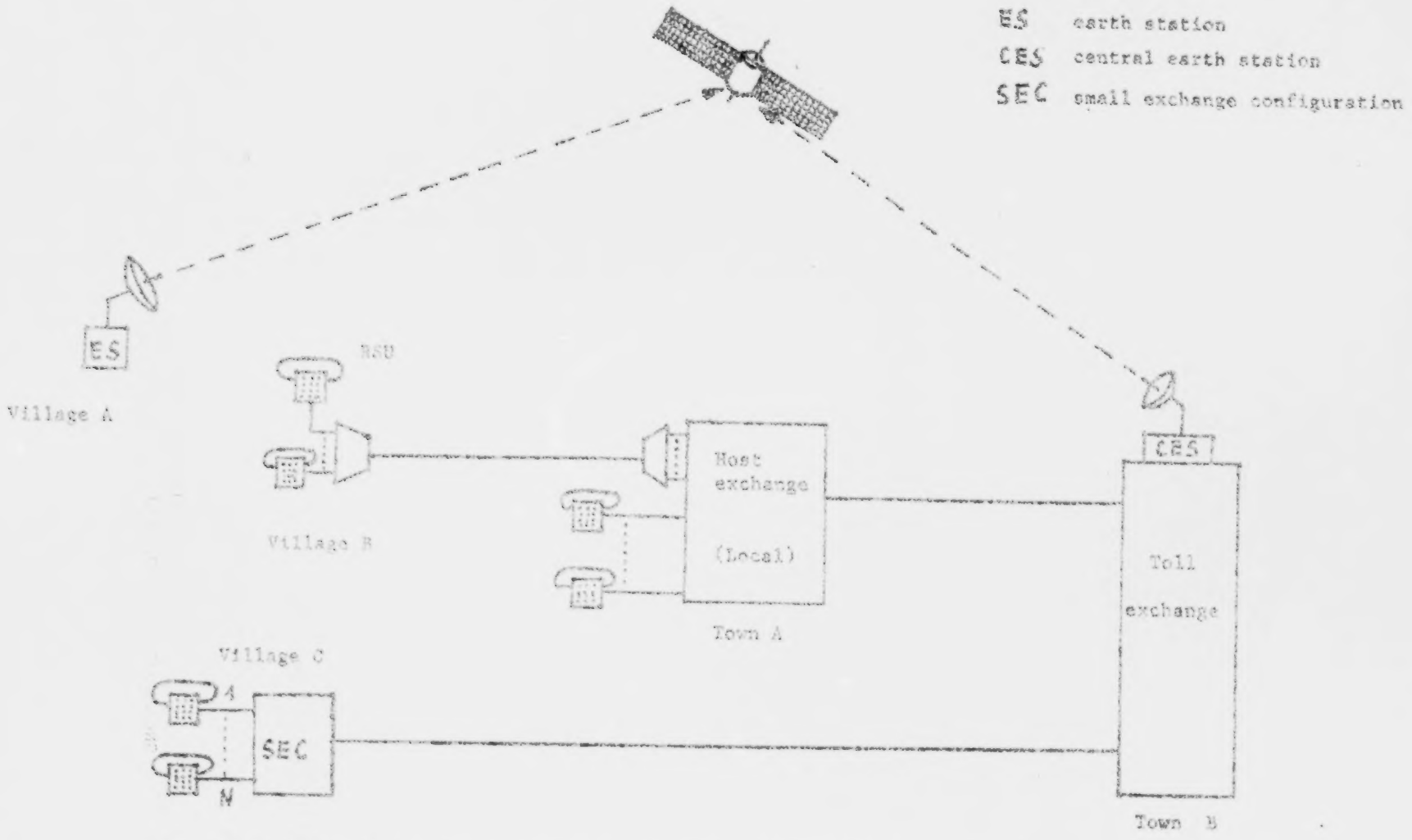


Figure 3.6. Modern switching technologies in rural environment: digital concentrator (village B), small exchange configuration (village C), rural satellite system with DAMA (switching takes place in CES).

4. IMPLEMENTATION OF RURAL TELECOMMUNICATIONS IN SELECTED AFRICAN COUNTRIES

4.1 Burkina Faso
4.2 Cameroon
4.3 Ethiopia
4.4 Malawi
4.5 Mali
4.6 Niger
4.7 Togo
4.8 Zimbabwe

4.1 Burkina Faso

4.1.1 The national telecommunication network
4.1.2 Rural telecommunication services
4.1.3 Example of investment costs
4.1.4 Power supply in rural areas
4.1.5 Aspects of O & M and quality of service
4.1.6 Economic impact of rural telecommunications
4.1.7 Tariffs
4.1.8 Summary

4.1.1 The national telecommunication network

The telecommunications network has been constructed and developed basically following the principal poles of economic and strategic interests. Consequently, important towns are being served whilst many, essentially rural or semi-rural areas are on the contrary deprived of these services. This imbalance has been dictated primarily by financial constraints coupled with considerations of profitability, which by the way is the case in all developping countries.

With the installation of the earth station and the introduction of digital technology, a considerable number of centres has been automated and interconnected by PCM cables and digital microwave links. At present, the network has the following parameters:

(i) Subsector of switching and local networks

- 1 semi-automatic international transit exchange (400 circuits);
- 1 electromechanical national and local transit exchange, the capacity of the local exchange is 4,800 subscriber lines of which about 1,800 are connected;
- 1 digital international/national/local exchange, the capacity of the local exchange is 8,000 lines of which approximately 7,000 are connected;
- 3 recently installed digital local exchanges with a total capacity of 1,200 lines, occupied at about 50%;
- 12 electromechanical local exchanges with a total capacity of about 12,000 lines, of which about 50% are connected;
- 35 localities have automatic services, either by local exchanges or by concentrators or by multi-access radiotelephone systems;

(ii) Subsector of transmission

- 2,150 km microwave systems of which 550 km are digitized, with 55 relay stations, among those 19 are solar powered;
- 1 interurban PCM cable with a total length of 220 km serving 7 places;
- approximately 2,700 km of open-wire lines, partly equipped with carrier systems.

(iii) Subsector of energy

In places where electric energy from the public network is not available, diesel generators and turbo-generators are utilized. They are progressively

being replaced by solar energy. For this reason, the majority of the relay stations are presently powered by solar energy.

4.1.2 Rural telecommunication services

Although more than 80% of the population lives in rural areas, the big towns have about 70% of the telephone lines.

Having in mind socio-economic promotion and disenclavement on the one hand and high investment costs in relation to the low demand and its scattered distribution on the other hand, Burkina Faso aims at providing a minimum telecommunication service to rural areas. Some important projects have been enrolled in the short-term development plan (1988-1993) which notably focuses at the utilization of multi-access radio systems (MAR), the technique of drop-insert of circuits on microwave links and the derivation of PCM on cables.

Already since 1986, ONATEL has gained good experience with two multi-access radiotelephone systems (IRT 1500), a third one has been installed during May 1989. Another system (IRT 2000) is supposed to be operational by the end of 1989, whereas the installation of two others will be starting soon.

Subscribers located along the microwave links are commonly connected by means of drop-insert techniques either directly (remote subscribers) or via concentrators. On the route of the PCM cable, four places are served by derivation of one PCM respectively. Whenever the demand will exceed the maximum capacity of 30 channels, concentrators would be installed. Also during 1989, ONATEL has put into service a system of concentrators using carriers on open wires. Some very remote places are still served by the classic means of open wire lines. However given its low service quality, this technique is disappearing. More details on systems for serving rural areas are given in table 4.1.

Figure 4.1.1 shows all MAR systems which are operational or under planning in Burkina Faso, and Figure 4.1.2 shows, as an example, the configuration of a MAR system having been put into service during May 1989.

4.1.3 Example of investment costs

The total costs for the MAR-system which is shown in Figure 4.1.2 were F. CFA 156,000,000 approximately US$ 520,000. On the basis of 119 subscribers connected to the system, the average investment cost per subscriber is about US$ 4,400.

4.1.4 Power supply in rural areas

Taking avantage of a very high insolation, Burkina Faso does not hesitate to make usage of this situation through powering the equipment by solar energy. This kind of energy is utilized for almost the whole of the rural telecommunication systems except for central stations and those local stations being connected to mains supply. Because of the good experience which has been gained with solar energy, ONATEL has decided to gradually replace all diesel generators by photovoltaic systems.

4.1.5 Aspects of O & M and quality of service

It has been noticed that modern installations for rural telephony do not create particular problems with regard to operation since they are practically free of maintenance. On the other hand, there are considerable damages caused in the periphery by lightning, particularly originated by bad ground connections of metallic support for self-supported cables. Lightning may contribute to the deterioration of subscriber cards. Consequently, a sufficient stock of cards must always be available in order to facilitate immediate fault clearance.

The service quality depends on the reliability of the equipment as well as on the efficiency of interventions in the event of faults.

Digital rural telecommunication systems are not limited to voice transmission, but do also allow the connection of telex and telefax terminals. In this situation, O & M services have to be adapted to modern technologies by making available well trained staff and adequate logistic means.

4.1.6 Economic impact of rural telecommunications

It is most evident that the projects carried out in Burkina Faso have allowed the disenclavement of very remote areas. In the absence of a scientific study on the economic impact of this project, inquiries have been made at the subscriber level.

The subscribers who have been interrogated confirmed that important savings are being made by utilising the telephone in comparison with costs for travelling and other disadvantages if the phone would not be available.

One company in charge of running a gold mine and which has been recently connected to the MAR system shown in the Figure 4.1.2 assets that during a week several car movements between the mine and the capital was saved. The distance between the mine and Ouagadougou is about 200 km and the expenses for each travel are estimated at F. CFA 50,000.

In addition, a considerable decrease of personel travels towards the capital during the week-ends has also been noted, simply because of the fact that there is now a possibility to communicate by telephone.

4.1.7 Tariffs

With regard to tariffs, there is no distinction between rural and urban subscribers, neither in the call fees nor in the monthly rental charges.

4.1.8 Summary

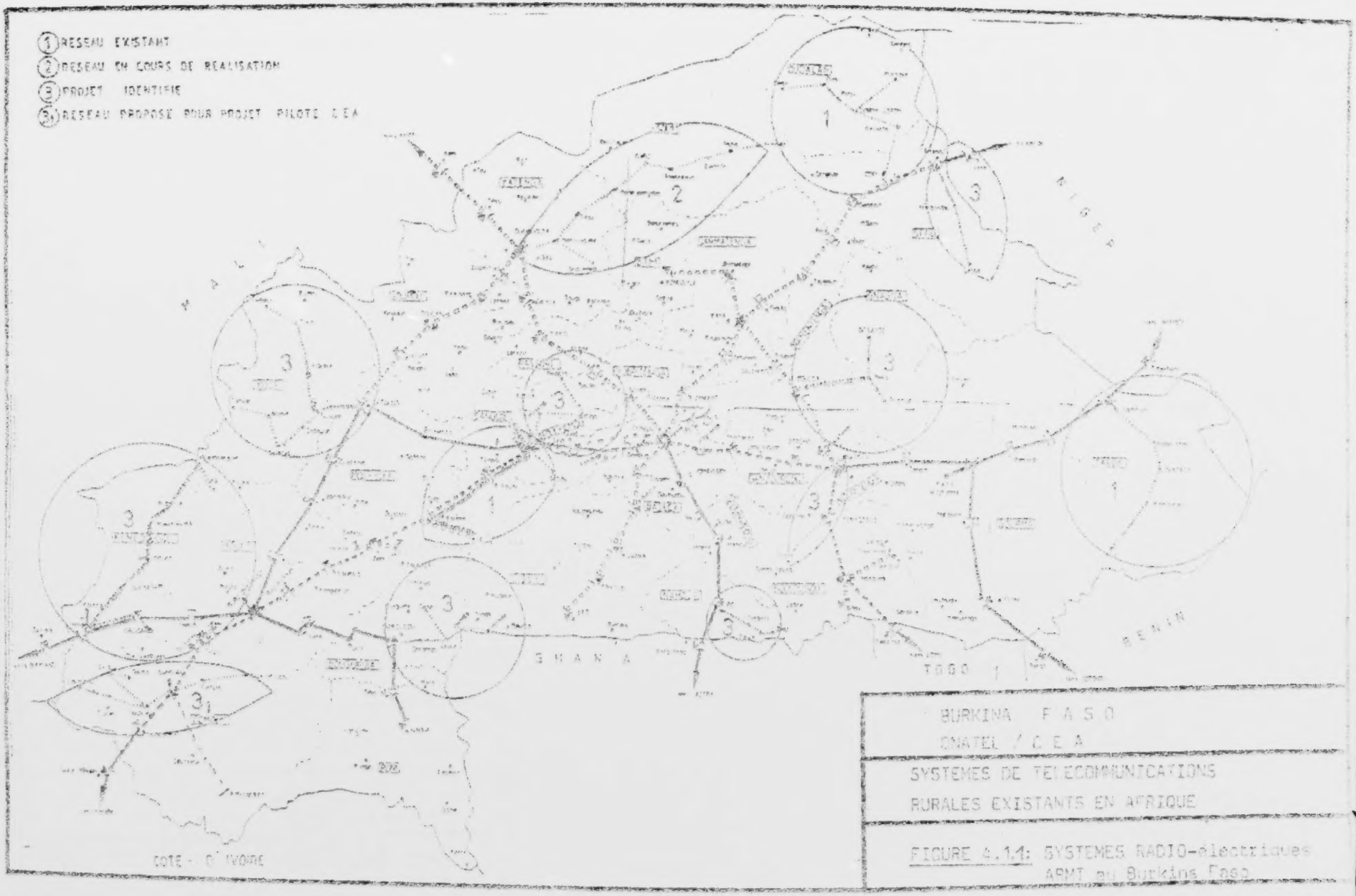
The experience made by ONATEL with modern rural telecommunication services is encouraging. An important part of the planning and installation

activities were undertaken by the Office itself and which for this reason has decided to carry on with this experience.

Although the modern technology is being mastered at this level, the deficiencies related to operation, namely the "customer service", require improvement.

Table 4.1 Rural Telecommunication systems utilized in Burkina Faso

	Equipment							
System	Type	Manufacturer	Installation	Number	Installed Capacity	Subscribers Connected	Power Supply	Observations
MAR	IRT 1500	TRT	1986	2	128	85	Mains (central stations) and solar energy	
MAR	IRT 1500	TRT	1982	1	128	102	Mains and solar energy	
Derivation of PCM on cables		Philips	1989	4	120	19	Solar energy	
Drop-insert on microwave links with and without concentrators		SAT TRT BBC	1986 - 1988	7	640	276	Solar energy	2 remote subscribers 1 mux; other systems with concentrators
Concentrators or carrier systems	CTR 160	MET Philips Telettra	1989	2	320	138	Mains	
Single-channel			1978 1982 1984	4	4	4	Mains and solar power	
Open wire								About 40 places are served



BURKINA F A S O
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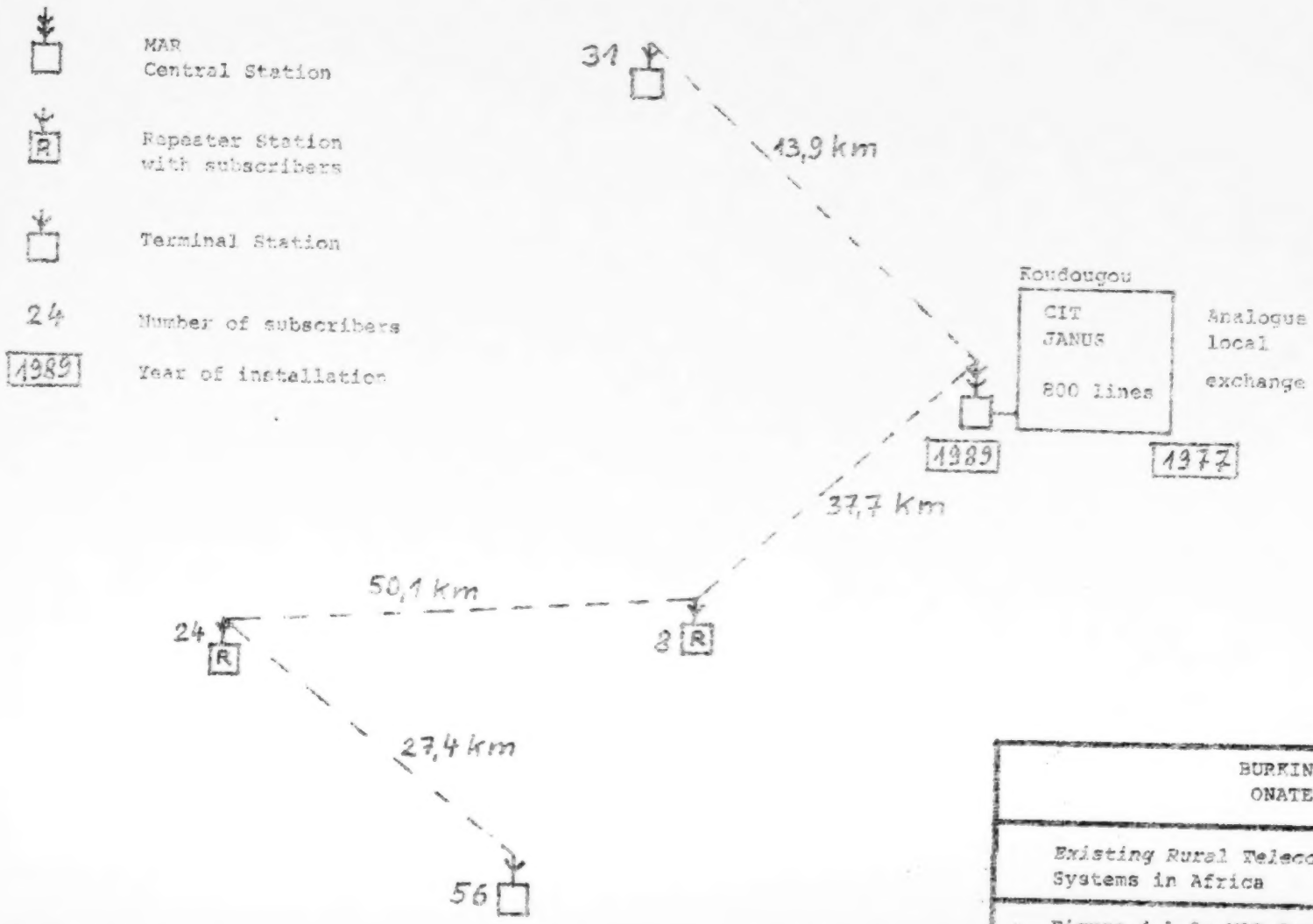
SYSTEMES DE TELECOMMUNICATIONS
RURALES EXISTANTS EN AFRIQUE

FIGURE 4.14: SYSTEMES RADIO-electriques
APMT au Burkina Faso



BURKINA FASO
ONATEL/ECA

Existing Rural Telecommunication Systems in Africa

Figure 4.1.2: MAR System configuration

4.2 Cameroon

4.2.1 The national telecommunication network
4.2.2 Rural telecommunication services
4.2.3 Example of investment costs
4.2.4 Power supply in rural areas
4.2.5 Aspects of O & M and quality of service
4.2.6 Economic impact of rural telecommunications
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4.2.8 Summary

4.2.1 The national telecommunication network

At present, the national telecommunication network of Cameroon is composed of electromechanical exchanges which are interconnected by analogue microwave systems. The number of subscribers connected to the telephone network is about 33,000, whereas the total capacity amounts to about 50,000 thus resulting in a relative low penetration of 0,33 line per 100 inhabitants.

Within the frame-wrok of the 6th development programme, the network will undergo an important extension since digital islands will be created in Douala and Yaounde, composed of 10 exchanges with a total capacity of 82,600 lines. It is also planned to make extensions with new analogue material in the remaining electromechanical exchanges. These operations are meant to satisfy the demand until the year 2000, and they will increase the installed capacity to 133,000 telephone lines.

On the eve of the introduction of digital technology which is programmed until the end of the year 1990, the configuration network is as follows:

(i) Subsector of switching and local networks

- 1 electromechanical international transit exchange;
- 1 digital international transit exchange;
- 2 electromechanical national transit exchanges;
- 5 electromechanical regional transit exchanges;
- 34 electromechanical local exchanges with capacities ranging from 200 to 10,000 lines and with a total capacity of nearly 50,000 lines of which about 33,000 are connected.

(ii) Subsector of transmission

- 2 earth stations, standard A, for international traffic;
- 1,750 km of high capacity analogue microwave links (1,260 channels plus tv signal) on the main route;
- there are spur-links connected to the main route with capacities ranging from 24 to 960 channels.

(iii) Subsector of energy

The microwave relay stations are generally powered by electric energy provided by the mains supply or by diesel generators.

Solar energy is not yet being utilized in the national network apart from some experiments in rural telecommunications.

4.2.2 Rural telecommunication services

Irrespective of the manual switchboards which today are out of service because of missing spare-parts, the rural areas are principally served by two techniques which are:

- Multi-access radio links (TDMA);
- analogue concentrators.

The introduction of rural systems into the automatic national network started in 1984 by the installation of two multi-access radiotelephone systems of the SR 100 type (SISEL Canada) in two places having very different climatic conditions, namely in equatorial and Sahelian climate respectively. The Cameroonian Administration observed the functioning of the equipment during one year before deciding to buy it after the experiments.

Now there are eight MAR systems working, namely six of the SR 100 type and two SR Intra call. The last ones are equipped with concentrators and their capacity varies from 6 to 60 lines having a final capacity of 94 lines. This kind of equipment is installed in rural areas with a very low telephone density.

The second technique utilized for serving rural areas, namely the analogue concentrators, is existing in two places, both of them being connected to their respective exchange by small microwave links. These concentrators of the T735 type (TELKON) allow the connection of 60 to 90 subscribers on a distant exchange by using 12 to 14 junctions. Local junctions can provide also local communications. The configuration of a T735 concentrator is given in Figure 4.2.1.

In addition to the above equipment, a concentrator of the CTR 160 type has recently been installed. It is supposed to be operational before the end of 1989. More details on existing rural systems are given in Table 4.2.

4.2.3 Example of investment costs

The cost of the SR 100 equipment amounted to nearly one billion Francs CFA (about US$ 3,333,000 at the present rate of exchange) for a total installed capacity of 245 lines, extensible to 345 lines. The cost includes training and spare parts. Calculated on this basis, the average cost per subscriber is about US$ 13,600.

As for the TELKON concentrators, the total cost for installation was about 300,000,000 F.CFA (US$ 1,000,000) concerning an installed capacity of 150 lines, including the subscriber network and the transmission equipment. In this case, the average cost per subscriber is US$ 7,200.

The Cameroonian Administration estimates, that the above costs are too high as to allow the project to the profitable, which is due mainly to the following reasons:

The MAR-system have been installed on the basis of turnkey contracts. The concentrators were purchased within a contract concerning cable networks, consequently the cost for the acquisition and installation of the switching equipment was increased by the commission due to the contractants.

In future deals, the investment costs per subscriber are supposed to be lower, since the Administration decided that a more important part of the works for planning and installation shall be executed by its own agents. Following this measure, the future average cost per subscriber line in rural areas is estimated to be around F. CFA 1,200,000 (US$ 4,000 at the present rate of exchange).

4.2.4 Power supply in rural areas

Whilst the concentrators are powered by mains supply, the subscriber stations of the MAR systems are solarized.

4.2.5 Aspects of O & M and quality of service

Generally speaking, the robustness of the equipment for rural telecommunications would allow them to operate satisfactorily under the climatic conditions prevailing in Cameroon. The maintenance of the concentrators is easy to do because of their modular conception and the possibility of replacing faulty cards. The operation of the SI 100 systems takes advantage of the existence of a centralized alarm system, which in fact is the case for all MAR-systems.

In spite of the strategic advantages, the quality of service is causing anxieties to the Administration, since the delays for fault clearings in rural areas are considerably longer than those for similar equipment in urban centers.

According to the findings made by the Administration, there are three principal reasons for this situation:

(a) the insufficient training of the technicians;

(b) shortage of spare parts implying the necessity to send defective cards to the manufacturers for repair;

(c) the agents in charge of operation show some lack of sensitivity with regard to the importance of rural areas for the national economy.

In order to remove the above inadequacies, the Administration has taken the following actions:

ad a) during future installation of equipment, technicians in charge of operation shall be associated to the works to obtain a solid field training;

ad b) regular stock-keeping of spare parts;

ad c) creation of a specialised task force for rural telecommunication techniques.

4.2.6 Economic impact of rural telecommunications

In the absence of a profound study on the economic impact, it is convenient to point out that the majority of the investments in the field of rural telecommunications is integrated into other development projects where they contribute to their profitability and efficiency.

4.2.7 Tariffs

The application of individual tariffs for rural areas has not yet been studied. At present, tariffs applied in these areas are those valid for the respective exchange to which they are connected. However, within the 6th quinquennial plan the telecommunications the Administration intends to elaborate a tariff policy for rural areas.

4.2.8 Summary

Cameroon has noticed that robust equipment may turn out to be fragile when placed into an inadequate environment. There are indeed fault delays of several months due to insufficient training of the technicians and also to the phenomenon that they attach less importance to telecommunications in rural areas than if placed in urban areas.

Before further expansion of rural telecommunications it will be necessary to improve the structure of operation and maintenance. Incidentally, actions have already been taken in this direction.

With regard to the technique, it is necessary to attach particular attention to the quality of earth connections to avoid damages caused by lightning.

Table 4.2: Rural Telecommunication Systems Utilized in Cameroon

Equipment								
System	Type	Manufacturer	Installation	Number	Installed Capacity	Subscribers Connected	Power Supply	Observations
Line concentrators with micro-wave links	T735-60	TELKON SAT		2	156	90	Mains	
Concentrator	CTR 160	CGCT	1989	1	160	under installation	Mains	To be put into service by December 1989
MAR	SR 100	SISEL		6	137	Under installation	Terminal station solar powered	
MAR	SR INTRA call	SISEL		2	120	Under installation	Terminal stations solar powered	

Figure 4.2.1: [illegible]

4.3 ETHIOPIA

4.3.1 The national telecommunication network
4.3.2 Rural telecommunications services
4.3.3 Example of investment costs
4.3.4 Power supply in rural areas
4.3.5 Aspects of O & M and Quality of service
4.3.6 Economic impact of rural telecommunications
4.3.7 Tariffs
4.3.8 Summary

4.3.1 The national telecommunication network

The present network is related to the grographical distribution of economic activities in the country and provides telecommunications facilities for urban and rural areas.

Service at the main centres is provided by using automatic exchanges. Manual exchanges are used for smaller towns. The Ethiopian Telecommunications Authority (ETA) had at the end of 1989 a total of 440 exchanges which provided 195,268 lines, 168,948 (86.5% of the total) were connected to 44 automatic exchanges and 26,320 lines (13.5% of the total) were connected to 396 manual exchanges. The two largest exchange systems at Addis Ababa and Asmara had 104,608 and 22,160 lines respectively, accounting for a total of about 75% of the total automatic telephone lines.

Digital Stored Programme Controlled (SPC) exchanges (L.M. Ericsson and FATME) were introduced in the network in 1988. There are 25 digital exchanges with about 75,648 lines and 7648 trunk circuits.

When digitalizing the network, the overlay method is mainly used, since the analogue switching equipment is not very old. The present analogue switching equipment is planned to be progressively replaced within fifteen years.

The long distance or toll-network in Ethiopia is based very largely on the use of microwave and UHF/VHF radio relay routes between the important towns and cities. The smaller places are served by open wire routes. Subscriber trunk dialling (STD) calls are set up between the telephone users in the 24 principal towns and cities. The implementation of a digital transmission network has already been commenced but as far as the national backbone routes and major regional routes are concerned, these are planned for the near future.

The characteristics of the telephone network are presently as follows:

Installed telephones	147,511
Installed main lines	117,014
Number of manual exchanges	396
Number of analogue automatic exchanges	19
Number of digital exchanges	25
Capacity of automatic exchanges	168,948
Channels on toll transmission lines	5,000
Channels on digital lines	1,400
Average of transmission links between:	
- Addis Ababa and primary centres	250
- Primary centres & terminal exchanges	100
- Primary centres & major manual exchanges	30

4.3.2 Rural telecommunication services

(i) Configuration of the terrestrial rural network

The simplest and low cost rural communication system employed is the "radio call system". Base stations with manual consoles are established at Addis Ababa and five places outside the capital. Radio call subscriber stations using solar panel transceivers are installed in the remote stations. Each base station can cater up to 50 subscribers on a time-shared basis. Some 90 rural public call offices have been established using the HF radio call system.

For shorter distances, within line of sight, individual subscribers or PCOs have been established using single-channel VHF systems and UHF multi-access systems. Five systems of the concentrated analogue radio system type have been purchased. The first system has been installed in 1988 in Nazareth area and the remaining four systems will be installed in different parts of the country in 1990. Where the traffic is too high to work the service on a shared basis, point-to-point circuits using HF or VHF are being used.

(ii) Small Earth Terminals

The use of a domestic satellite network is an alternative economic solution for the connection of remote stations to the HF point-to-point system and to the trunk network. An interim domestic route is at present in operation using single-channel per carrier (SCPC) facilities on the INTELSAT system. It is further planned to add this type of service in five isolated towns in 1990. Each earth station will be equipped to provide 4 telephone circuits and TV receive capability using 6m high performance antenna giving a G/T of 26.4 dB/^{o}k. The configuration of the domestic satellite network is depicted in Figure 4.3.1.

4.3.3 Example of Investment Costs

The investment costs for the five rural earth stations to be established in 1990 shown in Figure 4.3.1 amounted approximately to US$ 2,000,000 including the cost for engineering and training but excluding the cost of the remote station buildings. Hence the cost for one station equipped with 4 telephone channels and a TV receive circuit is about US$ 400,000.

4.3.4 Power Supply in Rural Areas

For the modern low power consumption raido-relay routes and rural telecommunications systems solar cells are most suitable and employed. The installed cost of a solar power supply is about US$ 30 per peak watt. ETA normally provides a storage battery having an autonomy of about 10 days, to allow for periods of low insolation and failures of the solar panels.

4.3.5 Aspects of O & M and Quality of Service

Steps were taken recently to reduce the number of faults on the telephone and telex lines by attending to the distribution points, the open wire lines and the drop wire. The call success rates were improved through replacement of worn-out exchanges by digital exchanges and better maintenance of others.

4.3.6 Economic Impact of Rural Telecommunications

The HF rural radio call project was conceived to provide basic communication to the rural areas of the country were normal telecommunications services were not provided. The rural radio call system is filling a definite gap in telecommunications services in the rural areas and enhancing the development of the country as a whole. However, the system has to be expanded to cover specific needs such as farms, villages, project areas, hospitals, health centres etc.

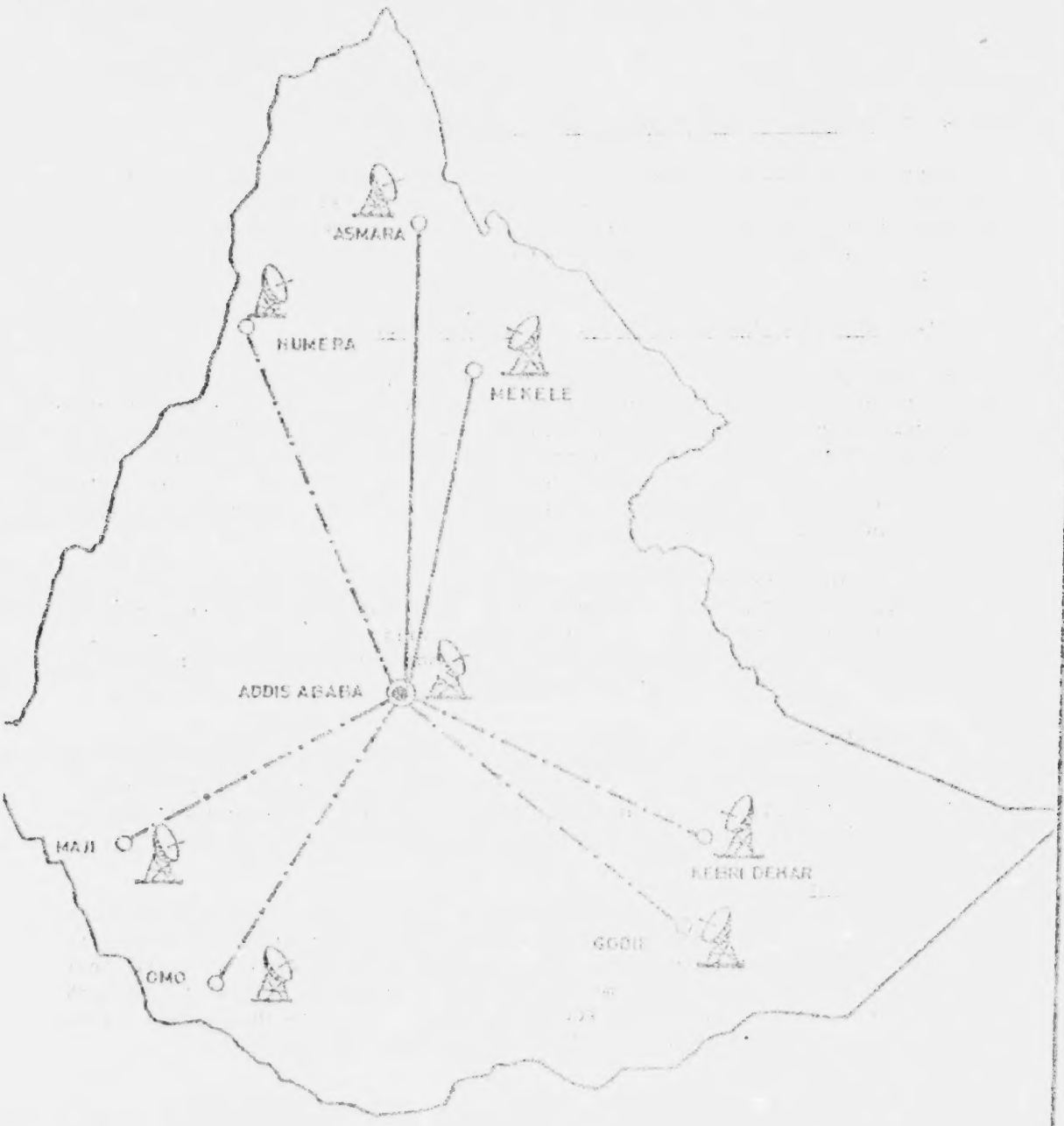
The economic impact is more obvious in the case of Single-Channel VHF Systems, Small Capacity VHF/UHF Systems and Multi-access radio systems because these are with automatic subscriber facilities. The single-channel VHF Systems are in the form of compact subscriber terminals and can be easily integrated with existing switching facilities.

4.3.7 Tariffs

The inter-urban tariffs are based on the time-distance relationship. Manually handled calls are treated on the same basis as subscriber dialled calls, with an additional charge for manual handling.

4.3.8 Summary

While PCOs in rural areas may be connected to the network by a variety of methods, determined principally by the PCO location, it is felt that Time Division Multi-Access Systems (TDMA) and a domestic Satellite network may best serve the majority of PCOs and thus contracts have been given for the introduction and expansion of these systems respectively.



LEGEND

——— EXISTING EARTH STN.

– – – – UNDER IMPLEMENTATION

ETHIOPIA
ETA/UNECA

Existing Rural Telecommunication System in Africa

Figure 4.3.1: Configuration of Domestic Satellite Network

4.4 MALAWI

4.4.1 The National Telecommunications Network
4.4.2 Rural Telecommunication Services
4.4.3 Example of Investment Costs
4.4.4 Power Supply in Rural Areas
4.4.5 Aspects of O & M and Quality of Service
4.4.6 Economic Impact of Rural Telecommunications
4.4.7 Tariffs
4.4.8 Summary

4.4.1 The National Telecommunication Network

Since the 1970s, the Department of Posts and Telecommunications (P & T) has concentrated on building up efficient urban and inter-urban networks, including a microwave network which interlinks the major urban centers. In the course of the 1980s, much attention was focused on increasing the rural coverage and improving the quality of service of the entire network.

Some 96 per cent of the 23,800 subscribers are connected to automatic exchanges, and there is a waiting list of about 30 per cent. According to a target of the telecommunications development policies, all telephone services are expected to be automatic by 1998, whereas international subscriber dialling shall be available to 99 per cent of the subscribers.

The existing telephone network is composed of different types of technology, made by a variety of manufacturers. Step-by-step, crossbar and digital switching apparatus are coupled to analogue and digital microwave and radio systems, cables and open wire transmission routes.

Digitization has in fact started at various levels, namely within a local/group urban exchange at Blantyre (AXE) which controls two remote switching units (RSU), in rural exchange configurations (UDX 5B, JISCOS) as well as in subscriber multi-acces systems (IRT 1500, NEC DRCS). Digital microwave backbone links were commissioned in 1989 and also a number of spur links are digitized.

The subscriber trunk dialling (STD) service is provided between automatic exchanges, and automatic international service to a number of countries is being offered in some exchanges through two satellite earth stations.

By the end of 1989, the Malawian telephone network was composed of the following:

(i) Subsector of Switching

- 1 analogue international transit exchange (SPC) at Blantyre,
- 1 electromechanical tandem exchange for national transit and terminal traffic at Blantyre,
- 1 electromechanical tandem exchange for terminal and local traffic at Lilongwe,
- 1 digital local exchange including two RSU with a total capacity of 4096 lines,
- 21 digital rural exchanges with capacities ranging from 56 to 512 lines and a further 13 exchanges to be implemented during 1990,

- 13 electromechanical local exchanges,
- 38 manual exchanges with a total capacity of 1726 lines,
- by mid 1990 digital exchanges within Blantyre will be extended by 15,000 lines.

(ii) Subsector of Transmission

- 2 earth stations of standards A and B respectively,
- 630 km UHF radio and analogue microwave links with capacities varying from 24 to 960 channels,
- 2264 km digital microwave links with capacities ranging from 30 to 1920 channels,
- 4 digital multi-access radiotelephone systems (MAR) being operational and a fifth one under construction,
- 49 single-channel radio systems,
- 800 km line-carrier systems on open wires, with and without subscriber dropouts,
- 60 km open wire lines.

(iii) Subsector of energy

Malawi has a comparatively high penetration of mains supply into the country. Therefore most of the microwave stations and many radiotelephone systems can be powered with energy from the public network. However, some microwave stations and remote stations of MAR and single-channel systems are solar powered.

4.4.2 Rural Telecommunication Services

Although considerable effort has been made in the field of rural telecommunications, many rural areas are still deprived of telephone service or have only very poor services. However, a number of remote areas have been connected to the network and many of the smaller exchanges are automated.

The rural population is served by 313 public call offices (PCO), sometimes located in postal agencies. On average there is one PCO available per 26,000 inhabitants, at an average distance of 16 kilometers.

The techniques applied for rural subscriber access-systems are varied, ranging from conventional technology (open wire with or without carrier

systems connected to manual exchanges), digital multi-access radiotelephone systems to small exchange configurations. Lastly, there are 49 single-channel radio systems serving as out of area DELs or trunks to small manuel exchanges.

A total of two MAR-systems (TRT) serving 102 subscribers is presently being operated. In due course, another three (one TRT, two NEC) will be implemented.

Capacities of digital rural exchanges vary from 56 to 512 lines. The largest configuration is the so-called "Thyolo tea area and Lower Shire telephone network", situated in the Southern Region, as it is depicted in Figure 4.4.1. All exchanges are autonomous with individual programme control. For transit and the purpose of centralized O & M control, they are connected to the Thyolo exchange by digital microwave links of 2 Mbit/s, 2 x 2 Mbit/s and 8 Mbit/s respectively. Departing from the most southern exchange (Nsanje), the service is extended by a digital MAR-system. Its function, however, is reduced to a point-to-point connection. Shortly, another MAR-system (IRT 1500) composed of 1 central station, 1 combined repeater/local and 2 local stations will be commissioned. That system will be based on the Luchenza exchange (slightly north-east of Thyolo).

Presently, 2,200 subscribers are connected to modern rural exchanges in various digital islands, and their number will increase considerably during 1990, when another 13 automatic exchanges of this kind will be implemented. Besides the above exchanges, Malawi serves an ever increasing number of subscribers by single-channel radio systems, of which the first has been operating since 1972.

Given the rather dynamic evolution with regard to modern technology, conventional equipment is shifted out as and when needed, however it is utilized virtually until the end of its technical life. About 3,700 subscribers are presently being served by the various systems, of which more details are given in Table 4.4.

4.4.3 Example of Investment Costs

The total investment costs including survey, installation and training of the two digital MAR-systems (NEC) presently under installation, and which are planned to be commissioned in 1990, amounts to Kwachas 3,139,000 (about US$ 1,163,000). The total capacity is 204 telephone and 4 telex subscribers, the average investment cost per subscriber line is calculated at US$ 5,500 approximately.

4.4.5 Aspects of O & M and Quality of Service

The staff in charge of the rural exchange configuration which is shown in Figure 4.4.1 has signalled a relatively high number of faults occuring within the system. The origin of the faults has a rather wide scale, ranging from hardware (faulty cards, tone generator,...) to software problems

(programme errors, watch-dog blocks,...). However, in the absence of an analytic fault diagnostic for each individual exchange and transmission link, a possible lack of performance of the equipment or of the maintenance procedures cannot be concluded at present.

As concerns the quality of service, subscribers are still relatively tolerant, notwithstanding some apparent technical problems, they seem to enjoy the improved performance of modern equipment.

4.4.6 Economic Impact of Rural Telecommunications

Obviously, the Malawian telecommunications administration, like many others in this survey, did not carry out scientific studies on the economic impact of their investments in rural areas. Conclusions have therefore to be derived from the acceptance of the new service by the public, one of the most important indicators being the revenues.

Taking as an example the pay-phones installed all over the network with many of them in rural areas, the monthly revenue coming from all 250 stations amounts to Kwachas 70,000 (about US$ 24,000). This corresponds to an average revenue of about US$ 100 per station. Experience shows, that the revenues tend to increase constantly, as and when the population gets used to the new "luxury".

Since its installation by the end of 1987, the revenues of a PCO (single-channel radio) in a rural community at a distance of about 40 kilometers to from the next post office, increased from monthly Kwachas 47 (US$ 17) to Kwachas 75 (US$ 27). This upward trend is evident from available receipts at the station. There are also many incoming calls on that line. In many cases, a phone-call saves a travel of a one or two days duration.

On the other hand, several lines are installed in tourist sites. Since the utilization by the visitors is very high, hotels are therefore demanding the installation of additional lines.

4.4.7 Tariffs

Malawi has not yet adapted its tariffs to the cases of calls coming from remote stations of single-channel or MAR systems. The effect is that calls over distances up to 40 kilometers or more are charged as local calls, as long as they end within the area of the exchange to which the station is connected. Basically, modern digital exchanges provide the possibility of discriminating remote subscribers with respect to the tariffs.

4.4.8 Summary

By serving about 3,700 rural subscribers, Malawi has a fairly well developed rural network with a high share of modern equipment.

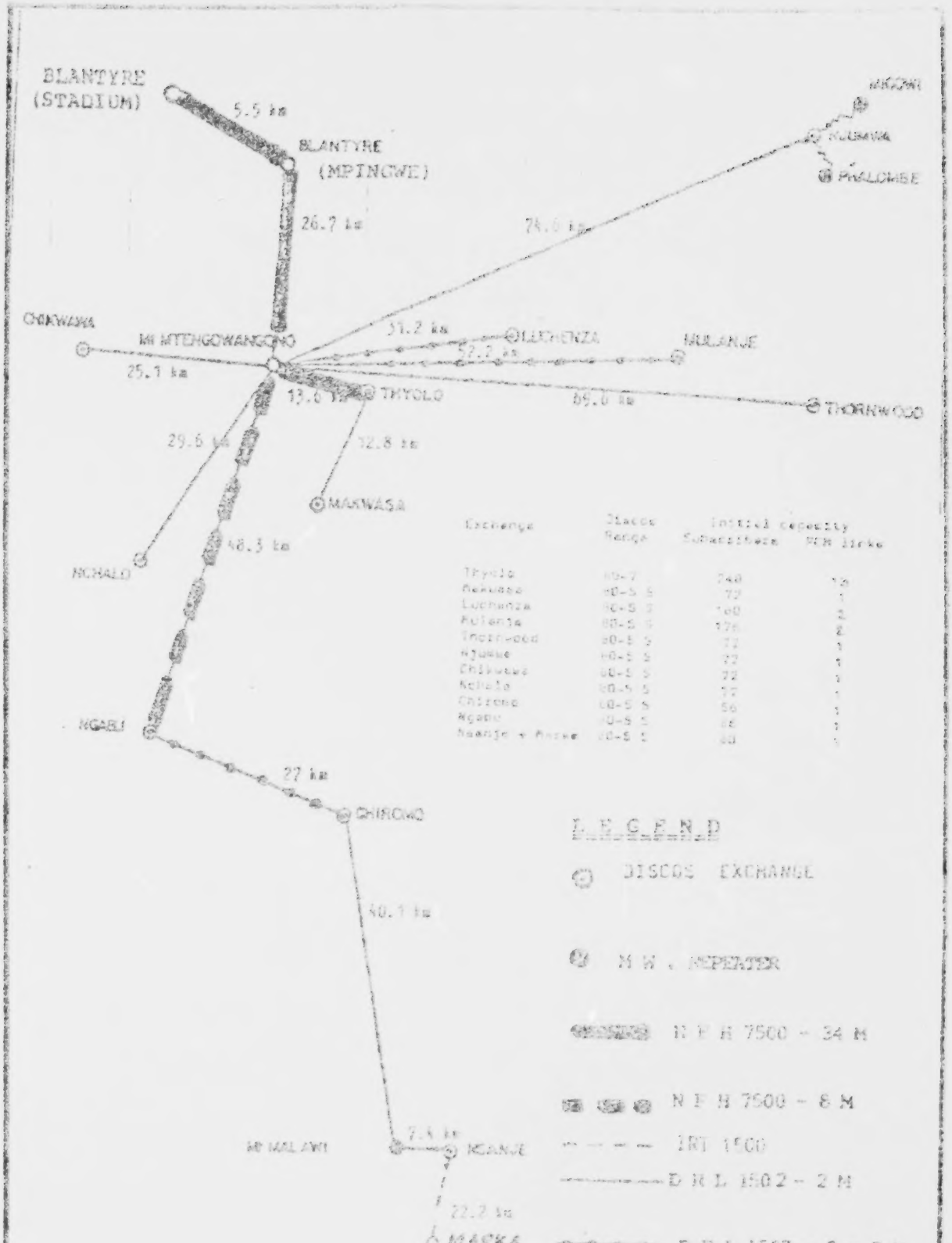
In comparison with other countries, the average investment costs per line are within the lower part of the medium range, which is quite reasonable.

There is a potential to reduce costs even more in the future, since up till now all projects have been executed on a turnkey basis. Having acquired more experience with the new systems, an important part of planning and installation might be carried out by P & T staff itself.

A centralized fault diagnostic might help to further improve O & M and the reliability of the rural equipment.

Table 4.4 Rural Telecommunications Systems used in Malawi

System	Equipment: Type	Manufacturer	Installation	Number	Installed Capacity	Subscribers Connected	Power Supply	Observations
Small digital exchange	JISCOS 80-7 80-5	Jeumont-Schneider	1986	17	2044	1400	Mains supply with standby	
Small digital exchange	UXD5B	GPT	1987 + 1990	4 + 13	1800 + 1540	800 + -	dto	
Small analogue exchange	Strowger		1980	4	345	174	dto	
Analogue concentrator	ARK	LM Ericsson	1983	2	400	140	dto	
Manual exchange (Magneto)				38	1772	945	Local battery	
Digital multi-access radio telephone (MAR)	IRT 1500	TRT	1986 + 1989	2 + 1	166 + 24	102	Mains supply + solar energy	
Digital multi-access radio telephone	DRCS	NEC	1990	2	204	-	Mains supply + solar energy	6 telex subscribers
Single channel radio system		Plessey Storno	1972 - 1989	49	49	49	Mains supply + solar energy	Some systems being used as trunks
Line carrier system on open-wire				20		925	Mains supply + solar power	Trunks to manual switchboards
Line carrier systems on open-wire				15	8-18 channels	125	Mains supply + solar power	Subscriber dropouts
Open-wire lines with manual exchanges					50	18		



REPUBLIC OF MALAWI
Department of S & T / UNECA

Existing Rural Telecommunications Systems in Africa

Figure 4.4.1: Typical Rural Telecommunication Configuration

4.5 Mali

4.5.1 The national telecommunication network
4.5.2 Rural telecommunication services
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4.5.4 Power supply in rural areas
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4.5.7 Tariffs
4.5.8 Summary

4.5.1 The national telecommunication network

The automatisation of the telephone network in Mali was initiated in 1975, whereas before that year the essential part of the interurban connections was operated on short-wave radio links and the rest on open wire lines sometimes provided with carrier systems.

The most important part of the present network is automatic at about 90%, because automatic exchanges are existing in all regional capitals. In general, the intra-regional traffic is operated automatically on analogue microwave links, but sometimes still on short-wave links.

Digitization started by the implementation of a national and international transit exchange (MT 20) at Bamako, then it continued by the installation of a combined digital local exchange (Jiscos) at Kayes. After a fire at the electromechanical exchange (Janus), a digital local and national transit exchange (E 10 B) was installed at Bamako in 1988.

An important number of places is equipped with manual switch-boards, however an important number of small villages have no telephone links at all at their disposal to communicate with the rest of the country.

The network is composed of the following elements:

(i) Subsector of switching and local networks

- 1 digital national/international transit exchange (660 lines of which 582 are operational).

- 15 electromechanical local exchanges with a total capacity of about 10,300 lines of which approximately 7,700 are connected;

- 2 digital local exchanges having a total capacity of 7,920 lines, of which about 5,750 are connected;

- 86 places are connected to the telephone network (automatic and manual exchanges, MAR systems).

(ii) Subsector of transmission

- 2 standard B earth-stations;

- 1,600 km of analogue microwave links with either 300 or 600 or 960 channels (equipment ranging from 60 to 360 channels with 28 relay stations);

- 480 km of digital microwave systems of 8 Mbit/s having 8 relay stations;

- 2 short-wave radio-links within the primary network;

- about 4,000 km of open wire lines;

- 2 VHF systems with a capacity of 24 channels each, of which 12 are connected.

(iii) Subsector of energy

Initially, all relay centres which were not powered by the mains supply, were equipped with turb generators. Progressively, they are being replaced by solar energy systems.

4.5.2 Rural telecommunications services

In order to effectively disenclave the rural areas within the country, OPTM intends to carry out, at short and long term in keeping with the government policy, the implementation and/or renovation of intra-regional links. The result of these measures shall be the basis for future serving of the rural areas.

By means of various techniques, 260 rural subscribers are presently connected to the national network, most of them (153) by three multi-access radiotelephone systems (MAR) of the IRT 1500 type. Tow MAR-systems are installed in an area which is composed of many villages being organized within the framework of an Office, the so-called "Office du Niger" (Office of the Niger).

The Office du Niger is specialized in the cultivation of rice and sugar-cane, the villages are scattered within a radius of 180 km approximately. Part of the district is a flooded area where it is difficult to use agricultural tracks (dykes) which are often interrupted by the water thus isolating the villages one from another.

The two MAR central stations are installed at an electromechanical local exchange having full routing autonomy. The Figure 4.5.1 shows the two systems which are subdivided in the Northern and Eastern network respectively, each network being basically configurated in the form of a chain with 5 repeater stations each. The most distant subscriber station is located at about 160 km from the central station. The number of subscribers is 128, which is half of the total capacity of the two sytems. Since the local exchange is saturated at 100%, it is not possible to further increase the number of subscribers connected to the rural systems which would make the systems more profitable.

A third MAR system serves some places in the surroundings of Bamako where the central station is located. The configuration is composed by one repeater station without subscribers and four local stations. Twenty five subscribers are connected to this system corresponding to a fill grade of only 20%. Figure 4.5.2 give a synopsis of all MAR systems in Mali, either installed or under planning.

There are 73 subscribers served by 2 analogue concentrators which are connected to their respective analogue exchanges via digital microwave links. The utilization of the drop/insert techniques on microwave links is also widespread thus allowing to serve a total of 37 subscribers.

Finally, 3 single-channel systems are operational since 1986. Up to the present, rural systems do not include non-voice services such as telex or telefax. For more detailed information please refer to the Table 4.5.

4.5.3 Example of investment costs

The investment costs of the two MAR systems being operated in the Office du Niger (Figure 4.5) amounted to FF 8,457,510 respectively about US$ 1,400,000. Consequently, the average cost per connected subscriber is about US$ 11,000. The investment cost of the system which is established in the rural area around Bamako, was FF 2,640,000, respectively about US$ 440,000, so that the average cost per subscriber (25 in total) is about US$ 17,600.

4.5.4 Power supply in rural areas

In the Northern network at the Office du Niger, all repeater and local stations except one are or should normally be powered by diesel generators. On the other hand, all stations of the Eastern network are solarized, except one. The two central stations, like their local exchange, are permanently powered by diesel generators.

When the systems were under planning, OPTM started from the notion, that the telecommunication equipment in certain places might by powered by the diesel generators already being operated there by firms. But it resulted later on that these generators either did not operate any more or at least their function showed irregularities, namely the tension supplied by them had important variation of the frequency. For the time being, the stations have been provided with truck batteries. The two existing sets are used alternately, whilst in the meantime one set is being recharged somewhere else. Given these problems, the service of one terminal station having only one subscriber has been suspended.

In the light of the very good results achieved when utilizing photovoltaic energy systems, it is now intended to equip all repeater and local stations accordingly.

4.5.5 Aspects of O & M and quality of service

Apart from open wire lines and short-wave links, the rural telecommunication systems operated in Mali are very modern. As a matter of fact, they don't create any problems, even when MAR systems are installed in places without air-conditioning plants. Although the solar modules need cleaning from dust from time to time and the acid level in the batteries

has to be controlled regularly, the equipment is considered to be maintenance free.

Nevertheless, subscribers sometimes complain of a reduced service quality which in the case of Mali has its origin in problems laying outside the systems for rural telecommunications themselves, namely in:

(i) reduced availability caused by power cuts in non-solarized stations which affect all stations following in the chain;

(ii) excessive delay in obtaining the dial tone due to traffic congestions in the parent exchange;

(iii) fading on radio-links passing over flooded areas (presently, the origin of the fading in the area of the Office du Niger is undergoing a study).

4.5.6 Economic impact of rural telecommunications

Many systems installed in Mali have penetrated into places which formerly were served by open wire lines connected to manual switchboards, but also to other places which before that time were deprived of telephone services. In the region of the office du Niger rice and sugar plants have been connected to the network (figure 4.5.1). The population has access to telecommunication services by using public call offices (PCO), and sometimes the amount of the revenues secured by them is amazing.

In a small town in the above region with 4 subscribers including one PCO the average monthly revenue of the cabin alone amounts to F. CFA 275,000 (US$ 520), 27% out of this originating from international traffic. Several places are inaccessible by road during the rainy seasons, and the telephone remains the only means of rapid communication.

The subscribers in the Bamako rural area asserted that they are able to utilize the phone like somewhere else. In addition to this comfort, the use of the telephone is considerably cheaper than the fuel which would be needed for necessary trips. Although the amount of money saved since the introduction of the MAR-system is not assessed, the economic impact is incontestable according to that source of information.

4.5.7 Tariffs

The rural subscribers in the region of the Office du Niger are connected to an analogue local exchange which does not discriminate the subscribers with regard to tariffs. Consequently all calls within the parent exchange area are taxed like local calls without limitation of duration.

The system installed in the Bamako rural area is based on a digital exchange, but also within this area all calls are taxed like those of urban subscribers.

4.5.8 Summary

With regard to the purely technical level, experiences acquired by OPTM with rural systems are positive. Considering the irregularities in the supply of electric energy by public and private services, the installation of photovoltaic systems turns out to be a necessity.

Although quite a lot of solvent customers are connected to the systems, there profitability is not at all evident, due to the low occupation grade and, consequently, a rather high average investment cost per subscriber. However, in the absence of an analytic accountancy this value cannot be precisely assessed for the time being.

Table 4.5 Rural Telecommunication systems utilized in Mali

System	Equipment: Type	Manufacturer	Installation	Number	Installed Capacity	Subscribers Connected	Power Supply	Observations
MAR	IRT 1500	TRT	1987	3	128 per system	153	1 diesel generator and solar power	3 stations are battery powered
Drop/inserts on microwave links without concentrators		Farinon	1988	1		37	Main an solar energy	
Digital microwave with analogue concentrator	CTR 160	NET	1986	2	320	73	Solar energy	
Single-channel	FM 800		1986	3	3	3	Solar energy	
Open-wire lines								18 places served
Short-wave radio links	CSF	Thomson						About 25 places served

TELEPHONIE RURALE DANS LES ZONES DE L'OFFICE DU NIGER
NIONO
DIABALI
DOUGOUNI
DIAKARIDIA
MACINA
DIA
DOUGABOUGOU
KONRI
KOLONGOTOMO
TENENKOU
TELEPHONIE RURALE DANS LES ZONES DE
DIENA
TOULKOUMBE
DOGNI
LARAMANE
DIELO
LES POINTS 1 + 2 + 3 + 4 CORRESPONDENT A
COFARA
BANDIAGARA
SANGHA ET
BANKASS
ALGERIE
MAURITANIE
SENEGAL
GUINEE
CÔTE D'IVOIRE
NIGER
TOMBOUCTOU
Bamba
Gao
Ansongo
Mopti
Ségou
Kayes
Bafoulabé
Bamako
Kita
Sikasso
Koutiala
Bougouni
Kankan
Odienné
Boundiali
Ferkessédougou
Korhogo
Bouaké
Yamoussoukro
Abidjan
LEGENDE
Centre de transit régional
Centre de groupement
Centre local
Faisceau hertzien
TELEPHONIE RURALE EN PROJET
TELEPHONIE RURALE REALISEE OU EN COURS
Z

4.6 Niger

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4.6.5 Aspects of O & M and quality of service
4.6.6 Economic impact of rural telecommunications
4.6.7 Tariffs
4.6.8 Summary

4.6.1 The national telecommunication network

The telecommunication network of Niger is organized around Niamey following two main axes, namely one microwave link (Niamey - Zinder) and a domestic satellite network connecting two centres (Agadez and Diffa) to Niamey, and which is completed by one microwave link (Agadez - Arlit).

The seven principal towns of the country are automatically connected to the national network, twelve other centres (sub-prefectures) have automatic local exchanges, but manual interurban traffic. Finally, 63 smaller places are provided with manual switchboards being connected to the national network either by microwave links or by radio links or by open wire lines).

There are three local exchanges in Niamey , two among them assume also the function of national transit. Another exchange is performing the international transit.

All exchanges are of various types of crossbar, whereas some transmission systems are of digital technology. The national telecommunications and the international terrestrial links are managed by the OPT Niger, but the international satellite communications are managed by the STIN (International Telecommunications Company of Niger).

The telecommunications network is characterized as follows:

(i) Subsector of switching

- 1 electromechanical international transit exchange;
- 12 electromechanical local exchanges (Crossbar) having a total installed capacity of 12,310 lines of which about 9,000 are connected; some of the above exchanges also carry out functions of national or regional transit;
- 39 manual exchanges with a total capacity of 1,150 lines of which about 700 are connected;
- 12 public call offices in rural areas.

(ii) Subsector of transmission

- 2 earth stations of which one is of standard A, serving international traffic;
- 3 standard B earth stations and 2 rural earth stations;
- 2,500 km analogue microwave links, the capacities varying from 1 over 8, 24, 36 to 600 channels or TV signal;

- 210 km digital microwave links with capacities ranging from 8 to 30 channels;

- 1 multi-access radiotelephone system (MAR) being operational and a second one is under construction;

- 1 VHF system (100 km);

- 1,300 km of carrier systems on open wire lines having between 3 and 15 channels (for interurbain links);

- 10 short-wave radio links;

- 1,600 km of open wire lines of which some have carrier systems (for rural telecommunications).

(iii) Subsector of energy

In connection with transmission systems, solarization is progressing rapidly. Already 22 relay stations without mains supply are provided with solar electric systems, whilst 9 stations are still powered by diesel generators.

Equipment for rural telecommunications in old technology are normally provided with local batteries. However modern systems are solar powered.

4.6.2 Rural telecommunication services

Niger is operating a vast scope of rural telecommunication systems, ranging from old technology to the very latest (see Table 4.6).

Where places are very scattered in desert areas, they can only be served by either short-wave radio links or domestic satellite systems.

As for satellite technology, Niger has been equipped with a domestic satellite network in 1981 which allows the operating of telephone and telex channels with two important centres not being served by the principal microwave system.

Two small earth stations both being equipped with 3 channels, have been added to the domestic network in 198[illegible] (see Figure 4.6.1). Each earth station is also provided with a TV channel.

The first digital multi-access radiotelephone system (IRT 1500) was installed in 1988 within the frame-work of a project for the economic development of the Liptako-Gourma subregion. At present, 5 subscribers are connected to this system which has a final capacity of 128.

A second MAR system (SR 100) is under construction whilst this report is being prepared. It is planned to be operational by the end of 1989.

For the first time, 25 subscribers will be connected to that system which has a total capacity of 96 subscribers.

The technique of carrier systems on open wire lines has been applied since 1964 up till now on 8 systems serving in total about 200 subscribers. These systems are characterized by a fairly low energy consumption, the longest distance of about 180 km is covered without the need of intermediate amplification. Small places on the route of the line are being served without the necessity of demodulation by using a baseband channel which may be interconnected from station to station.

About 150 rural subscribers are connected to remote exchanges by means of mini-links with capacities of to 5 channels in analogue technology, respectively, 30 channels when using PCM. Usually, mini-links are terminating on manual exchanges, but there are also remote subscribers connected.

The OPT is also operating 10 short-wave radio links which were put into service between 1980 and 1984 to serve remote rural places. Incidentally, open wire lines are still playing a very important role to serve isolated subscribers.

4.6.3 Example of investment costs

The investment costs for the two rural earth stations shown in the Figure 4.6.1 amounted to FCFA 600,000,000 approximately US$ 2,000,000 including the cost for engineering and training of staff.

Consequently, the cost for one station equipped with 3 channels and a TV circuit is about US$ 1,000,000.

4.6.3 Power supply in rural areas

As indicated in Table 4.6, most of the rural telecommunication equipment is solar powered, especially as far as modern systems are concerned. The distant stations of the short-wave links are powered by diesel generators, however for manual switchboards at the course of open-wire lines, with or without carrier systems, local batteries are used.

4.6.5 Aspects of O & M and quality of service

The OPT does not face any major problems with regard to operation and maintenance of modern equipment such as domestic satellite systems and digital transmission links, which is also true for solar energy systems. Nevertheless, the MAR system which was put into service in 1988 has a reduced service quality since the radio signal of the local stations as well as of the repeater station tends to disappear in the rainy season during thunder storms. The interruptions may last up to 10 hours, which may occur several times during one month. The origin of that phenomenon is not yet known

(fading, energy cuts, ...).

As concerns the carrier systems on the 180 km open-wire line, perturbations by excessive noise are often noticed which apparently have their origin in the relative high atmospheric humidity during night-time.

Generally, the rural telecommunication systems work without specific problems, but some trouble is caused regarding the flux of traffic at the interfaces with urbain systems caused by bottlenecks like in the Niamey network.

4.6.6 Economic impact of rural telecommunications

The penetration of telecommunications into the rural environment has noticeably improved the administrative methods as well as the personal security of its population. In rural areas, the authorities of Niger are the principal users of the services. The population is reluctant in requesting the installation of telephone lines, although there are free capacities available. Apparently, this behaviour is due to the relatively low purchasing power in rural areas in front of the level of installation fees, namely F.CFA 83,000 (about US$ 280) for one telephone line (including a guarantee deposit of 50,000 F). Generally, the rural population contents itself with using public call offices as and when needed. PCOs are normally installed in the post offices.

The economic impact is more obvious in the case of the MAR system which has been installed in 1988. One of the subscribers is a tourist hotel located in a safari park (Parc du W), and another one is the conservative of that park. Many hotel guests make use of the modern communication facilities existing at a distance of 150 km from the capital.

4.6.7 Tariffs

Generally, the taxes for incoming and outgoing communications in rural networks are the same as used for interurban communications. This is facilitated by the fact that nearly all communications have to pass through manual switchboards. For the same reason, interurban communications of PCOs connected to the MAR-system have to pass through the switchboard.

4.6.8 Summary

Presently, like already in the past, Niger is decided to disenclave its vast rural areas by making available telecommunications in conventional as well as modern technology. In those areas, the telephone is primarily used by the administrative services and, to a less degree, by the population using public call offices. Although those projects are not economically viable, their implementation is provided through political intentions.

The experiences are with the modern systems such as small digital microwave links, rural earth stations and one multi-access radiotelephone

system. Only the operation of the latter one has still some technical problems (disappearance of stations during the rainy season).

With regard to the photovoltaic systems, the experiences acquired by Niger in that particular field are very positive.

Table 4.6: Rural Telecommunications Systems used in the Republic of Niger

EQUIPMENT								
System	Type	Manufacturer	Installation	Number	Installed Capacity	Subscribers Connected	Power Supply	Observations
Digital multi-access radio telephone MAR	IRT 1500	TRT	1988	1	40	5	Solar energy and mains supply (Central station)	
Digital multi access radio telephone MAR	SR 100	Intel-con	1989	1	96	25	Solar energy and mains supply (Central station)	To be operational by December 1989
Analogue small microwave	FHM 452 TFH 557	SAT Thomson	1974-1976	4 + 2	10	75	Solar energy	
Carrier systems on open-wirelines with man switch boards		Telettra secre	1964-1986	8	45 channels	200	Solar energy, local battery	
Short-wave radio		Thomson	1980-1984	10	12 channels	20	Mains supply and diesel generators	
Open-wire lines						250		Estimated figure
Digital small microwave	FH050	Thomson	1986	2	42	70	Solar energy	
Domestic satellite		Telespace	1989	2 stations	6 channels	9	Solar energy	Bilma and Tchintabaraden

Légende

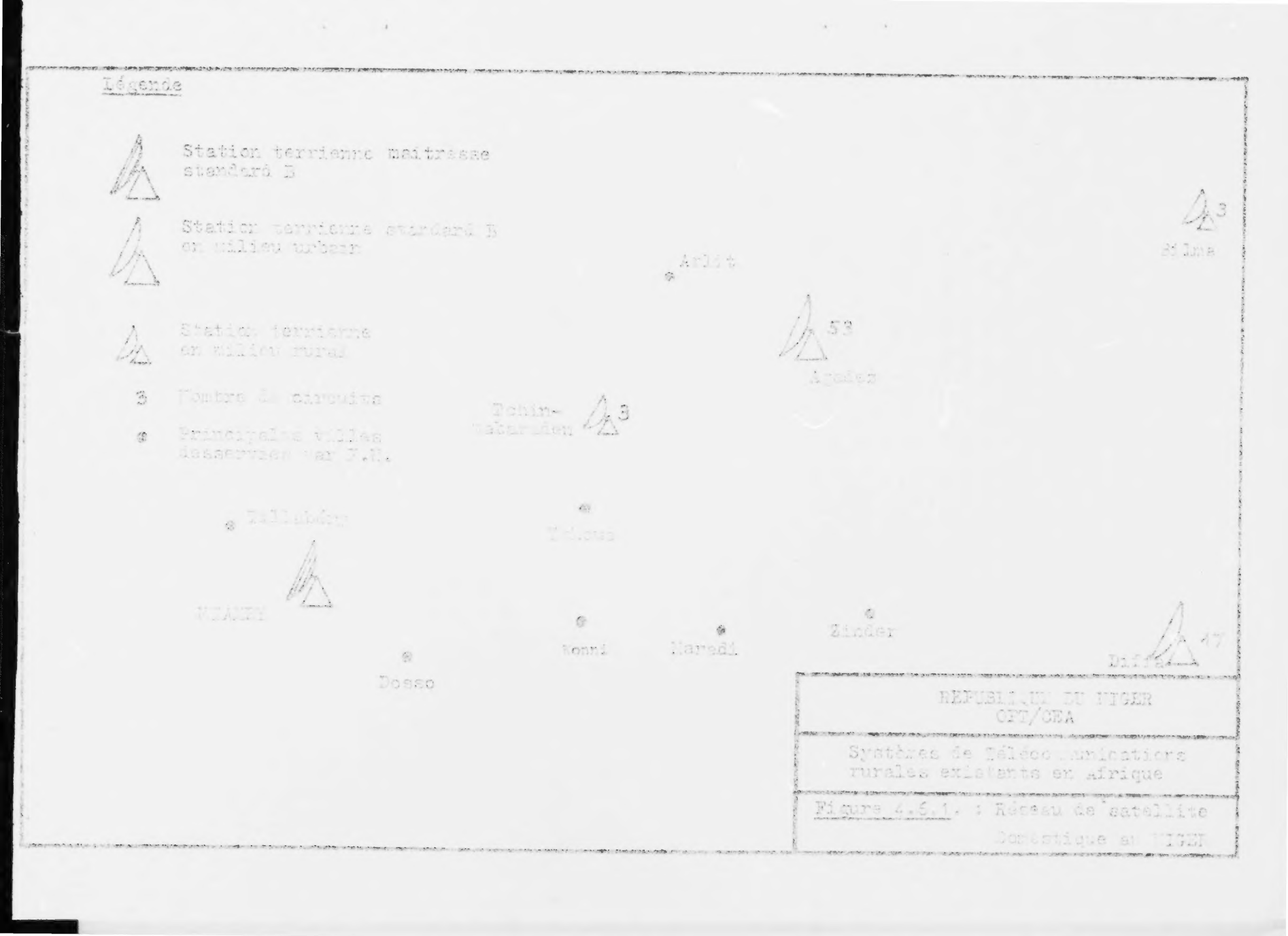
Station terrienne maîtresse standard B

Station terrienne standard B en milieu urbain

Station terrienne en milieu rural

3 Nombre de circuits

Principales villes desservies par S.M.



REPUBLIQUE DU NIGER
CNT/CEA

Systèmes de Télécommunications rurales existants en Afrique

Figure 4.6.1. : Réseau de satellite domestique au NIGER

4.7 TOGO

4.7.1 The national telecommunication network
4.7.2 Equipment for rural telecommunication utilized in Togo
4.7.3 Example of investment costs
4.7.4 Power supply in rural areas
4.7.5 Aspects of O & M and quality of service
4.7.6 Economic impact of rural telecommunications
4.7.7 Economic impact of rural telecommunications
4.7.7 Tariffs
4.8.7 Summary

4.7.1 The national telecommunication network

The telephone network has 10,000 main lines of which about 9,200 are connected to automatic exchanges. It is located around the main transmission axis which consists of analogue microwave links having a maximum capacity of 960 channels, serving the 5 county towns on their route. The links between the county towns and their prefectures are provided either by small digital microwave links or by open-wire lines.

The telephone network comprises 9 electromechanical automatic exchanges (Penta), the most important one being installed in Lome. The capacities range from 148 to 8,280 lines.

The national telecommunications are managed by the Post and Telecommunications Office of Togo (OPTT), whereas the Lome earth station and the international transit exchange are managed by the "Autonomous International Telecommunications Company of Togo" (SATELIT).

A network modernization is under preparation aiming at the digitization of all automatic exchanges and the transmission network including fiber optics, to be achieved until 1992. The activities will include the subscriber networks of all places where exchanges or remote switching units will be installed, thus increasing the installed capacity to 23,000 telephone lines.

In the eve of projects for modernization, the network is composed as follows:

(i) Subsector of switching and local networks

- 1 electromechanical international transit exchange;
- 1 electromechanical national transit/local exchange;
- 9 automatic exchanges having a total capacity of about 10,000 lines of which 9,500 are connected.

(ii) Subsector of transmission

- 1 standard B earth station for international traffic;
- 687 km of high capacity analogue microwave links (960 channels);
- 166 km of small capacity digital microwave links (1 to 8 PCM);
- 120 km open wire lines with carrier systems;
- 870 km low frequency open wire lines.

(iii) Subsector of energy

All repeater stations except one of the main transmission links are powered either by mains supply or by diesel generators. The remaining station is powered by a photovoltaic system (2 x 3,200 Watts peak) since about three years.

4.7.2 Equipment for rural telecommunication ujtilized in Togo

On the level of the most recent techniques there exists equipment in Togo which is normally used for rural areas, but it has to be made clear, that in the present case it is utilized to serve places having a certain administrative and/or economic importance.

Apart from the nine towns in Togo being provided with an automatic exchange, the rest of the country may be classified as the domain of rural telecommunications. This does not only refer to villages and small rural places, but also to towns having a certain importance.

Generally, rural areas are being served by manual switchboards which are connected to the national network by open wire lines covering a distance of up to a several dozens of kilometers.

With regard to more recent techniques, there are basically three different transmission systems utilized for serving rural areas:

(a) one digital multi-access radiosystem (SR 100) including the central station, one repeater station (without subscribers) and one terminal station (60 lines) which was put into service in May 1989;

(b) one small analogue microwave link (24 channels) to serve a small analogue exchange (200 lines);

(c) two small digital microwave links (1 PCM each, respectively Thomson and Nokia) to connect two small analogue exchanges (140 lines) to the national network;

(d) one small digital microwave link (1 PCM, Nokia) ending on a manual switchboard (44 subscribers) and which also carries two remote subscriber lines;

(e) three small digital microwave links (1/2 PCM, SAT).

The small microwave systems were installed between 1982 and 1989 to make existing exchanges more profitable, which were formerly connected to the national network by open wire lines thus allowing automatic service only for local traffic.

The Figure 4.7.1 shows a configuration in which the channels from one PCM are distributed on two digital mini-links in order to serve one small automatic exchange and one manual switchboard respectively.

For more details on systems which are installed in Togo, please refer to Table 4.7.

OPTT intends to give more importance to rural telecommunications as soon as the network will have been digitized.

4.7.3 Example of investment costs

The investment costs for the above MAR-system, equipped for 60 subscribers, amounts to US$ 185,000, i.e. US$ 3,000 per subscriber on average. The very favourable average cost results from the fact that the subscriber network is not included. Furtheron, savings were made by using old poles which have been rehabilitated. It should also be indicated that practically the whole of the planning and installation works (except pole mounting) have been executed by the Office's staff.

The costs of a configuration of two microwave links installed in series, as depicted in the Figure 4.7.1, amounted to F.CFA 53,000,000 in the year 1980, or about US$ 176,000. Thus, the average cost per system is US$ 88,000.

Taking as an example the automatic exchange for 148 subscribers which had an average cost of US$ 400 per subscriber line in the year 1971, the total investment cost per installed line summed up to about US$ 1,000 without the costs for the subscriber network.

4.7.4 Power supply in rural areas

All systems indicated in paragraph 4.7.2 are powered by the mains, except one repeater station which is solar powered.

4.7.5 Aspects of O & M and quality of service

Likewise most of the African countries, Togo made the experience that the quality of transmission as well as the availability of open wire lines on long distances are very poor. Faults causing disruption of links during several days are quite frequent.

(a) During the tests for putting the MAR-syustem into service during May 1989, a pertubing signal of a strange frequency, coming from a nearby transmission system, prevented the synchronization between the terminal and the central station. The effect of the pertubing frequency could be softened down by change of the antenna polarization, but nevertheless there were intermittent cuts of the connection, so finally it was necessary to modify the frequencies of the MAR-system.

(b) With regard to the small automatic exchanges connected to the mini-links, these are generally working satisfactorily. But there are considerable problems with the recovered analogue

microwave link, since faults occur frequently within the channel modulation cards of the multiplexor. Since fault-clearing delays for these cards may be excessively long, the link happens sometimes to be reduced to half of its initial capacity.

(c) On the other hand, there is no problem with the operation of the digital microwave systems.

4.7.6 Economic impact of rural telecommunications

The economic impact of rural telecommunications can be assessed quite easily, as far as they penetrate into isolated areas. In Togo, however, the regions concerned had already been served earlier by either manual switchboards (in the case of the MAR-system) or by automatic exchanges. In most cases, old transmission systems by open wire lines have been replaced and the economic impact therefore results mainly in an improved service quality.

The chief of an exchange located in the town which is the head office of the Company for the renovation of cocoa and coffee and which also receives many tourists, has asserted that the revenues coming from the PCO and other subscribers have increased by 100 per cent since the microwave system was installed. As a matter of fact, the exchange has been utilized more efficiently since then. Evidently, the subscribers were ready to spend more money for telephone services, when they were able to make savings in other fields.

4.7.7 Tariffs

The subscribers of the MAR-system are connected to the exchange in the Capital and they are taxed like any other subscriber of that exchange. Regarding tariffs, the other systems don't show any particularities, since the transmission links are connected to automatic exchanges.

4.7.8 Summary

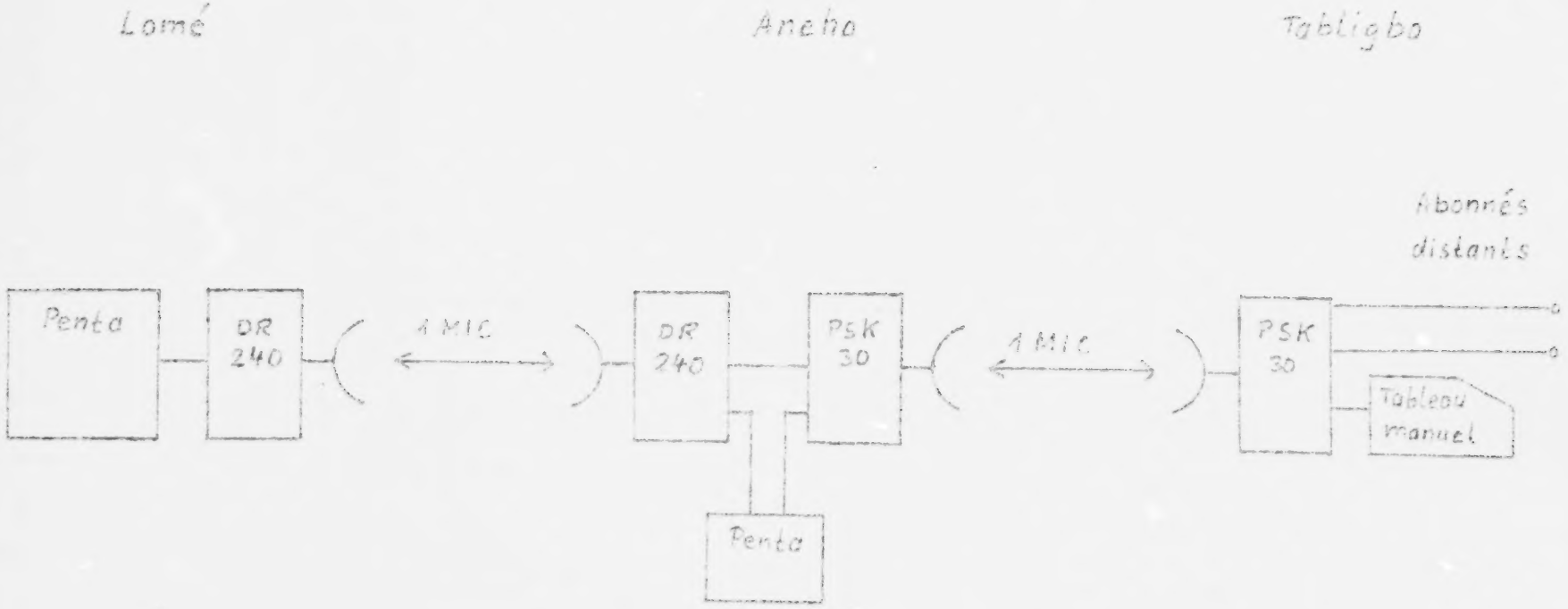
Togo's experience with modern rural telecommunication systems are still limited, because they have not been operational for a long time. However, it has already become evident that digital MAR-systems are likely to be perturbated by strange frequencies. It is quite possible that this phenomenon might show up more often in the future, as and when the number of these systems will increase in African countries. It will be necessary to consult neighbouring countries on the utilization of frequencies, especially in boundary regions.

The procedure for repair of transmission equipment needs to be improved. In fact the service quality of a transmission link was being reduced by congestions caused by missing channels which consequently was leading to less revenues.

After three years, Togo shall have many possibilities to improve its rural services, since by then they will be based on a digital telecommunications network.

Table 4.7 Rural Telecommunication Services Utilized in Togo

Equipment								
System	Type	Manufacturer	Installation	Quantity	Installed Capacity	Subscribers connected	Power supply	Observations
MAR	SR 100	SRT	1989	1	60		Mains	To be put into service by November 1989
Microwave	FH 632	Thomson CSF	1988	1	12 channels	187	Mains	Re-used equipment
Microwave	MX 647 DR 240	Thomson Nokia	1982	1 1	1 PCM		Mains	
Microwave	FHM 914	SAT	1983 1984	3	1/2 PCM		Mains	



REPUBLIC OF TOGO.
OPTT/ZCA

Existing rural telecommunication Systems in Africa

Figure 4.7.1: Small digital microwave System

4.8 Zimbabwe

4.8.1 The National Telecommunication Network
4.8.2 Rural Telecommunication Services
4.8.3 Example of Investment Cost
4.8.4 Power Supply in Rural Areas
4.8.5 Aspects of O & M and Quality of Service
4.8.6 Economic Impact of Rural Telecommunications
4.8.7 Tariffs
4.8.8 Summary

4.8.1 The National Telecommunication Network

The greatest development of the telecommunication network occurred along the early railway line on which the main towns now stand. In recent years there has been a shift of emphasis for development to the remote parts of the country. For many villages, apart from gravel roads, a telecommunication link is the only possible means of communication, the source of information being the radio.

The telephone exchanges are analogue (Strowger, Siemens EMD) and digital (AXE 10, FETEX 150) with a total installed capacity of 162,712 lines and an exchange fill with about 130,000 lines. Open wire carrier systems are used for most of the rural exchanges providing 1-12 channels (STC/Telettra).

FDM radio systems are also in use, mostly for major and high capacity links (960 channels), middle capacities (up to 300 channels) and low capacities (24 - 120 channels).

Presently, the telephone network is composed as follows:

(i) Subsector of Switching

- 1 digital international transit exchange (AXE 10),
- 3 analogue and 2 digital regional transit exchanges,
- 93 electromechanical local exchanges with a total capacity of 156,075 lines,
- 12 manual local exchanges with a total capacity of 825 lines,
- 113,500 lines (automatic/manual) working.

- (ii) Subsector of transmission

- 1 standard A satellite earth station (AOR)
- 1,800 km of analogue microwave links, ranging from 60 to 1,800 channels,
- 1,500 km of digital microwave links, ranging from 480 to 1,920 channels,
- 3,150 km of open wire carrier systems,
- an undetermined length of open wire lines,
- 8 multi-access radio systems operational and one under construction

(iii) Subsector of Power Supply

The availability of commercial power in Zimbabwe is good and the majority of the relay stations on the existing network are supplied by that source. Some of the subscriber access systems use local batteries, whereas outstations and repeater stations of MAR systems are generally powered by photovoltaic equipment.

4.8.2 Rural Telecommunication Services

The objectives of introducing rural telecommunications were to

- arrest population drift from rural to urban centers,
- create employment closer to rural areas themselves,
- provide and create catalytic infrastructure and services for development.

In Zimbabwe, there are two distinct types of socio-economic communities, namely

- commercial farming and urban areas,
- communal lands.

In order to promote rural development, in 1980 four different types of rural centers were created and developed for the integration and efficient operation of an economic system:

(i) Business centers
(ii) Rural service centers
(iii) District service centers
(iv) Growth points

The government also decentralized policy and set up new industries, supply depots and wholesale enterprises. This resulted in an urgent demand for telecommunication by the centers.

A rural development programme was elaborated by PTC to define the objectives for meeting the growing demand. It consisted mainly in upgrading and replacing the conventional techniques such as manual exchanges, trunk systems, party-line systems as well as the adoption of new technologies for distribution, namely multi-access rural radio systems, concentrators and small capacity radio systems.

In the course of the rural development programme, 40 manual switchboards were replaced by electromechanical automatic exchanges (Strowger) with capacities ranging from 100 to 600 lines. An important part of the line capacity was assigned to remote subscriber access systems.

To replace obsolete party-line systems, an electronic party-line system (EPL) was designed and developed within the PTC. There is still a great demand for this kind of equipment which is being manufactured locally with financial support from the ADB and the EDF. Up to 8 subscribers may share one exchange line, and the system provides additional features such as privacy of communication, selective ringing, STD access, call back facilities and reverting calls (i.e., one party-line subscriber calling another subscriber within the same system).

Carrier systems are not only utilized for overhead trunks, but also for subscriber access, most of the old systems (SOR 10) being progressively replaced by new types (PST L 12 and TD3/N respectively).

To cover areas with rugged terrain, hills, dams, rivers and small pockets of subscribers, MAR systems are used. Two types of this kind of technique were introduced into the Zimbabwe network, namely SR 100 (SRT Canada) and IRT 1500 (TRT France).

Up till now, seven SR 100 systems have been installed with a total capacity of 653 subscribers and a total fill of 211 subscribers. One IRT 1500 system is operational and another one is presently under installation to be commissioned by the end of 1989. Furthermore, one TRT 2000 is scheduled to be installed during 1990. A typical application of a MAR system is depicted in Figure 4.8.1.

According to a technical review of the MAR systems carried out by Teleconsult of Canada, the utilization of the systems is low which results in less than expected revenues. The low utilization has been attributed to a number of factors. For one system there was an inaccurate demand forecasting while for others a need was identified for additional distribution materials for the systems to be used to full capacity. This situation has been corrected since then and utilization should improve as service develops. (Source: Document No. 19 of the Bibliography).

As concerns system engineering, PTC is in a position to largely rely upon internal resources. It has already shown the capability to carry out system design activities such as radio propagation and path design up to installation of systems. More details on existing rural telecommunication equipment are given in Table 4.8.

4.8.3 Example of Investment Costs

The total costs for 4 MAR systems (equipment and local expenses) during the years 1986 and 1987 amounted to Zim$ 2,600,000 which was at that period the equivalent of US$ 1,600,000 approximately. The four systems having a total installed capacity of 245 subscribers, the average cost per subscriber was about US$ 6,600.

4.8.4 Power Supply in Rural Areas

In a "typical" rural area, mains supply is normally not available. Photovoltaic systems are used which generally work satisfactorily.

However, in the case of the first installed MAR systems, solar energy equipment has been the origin of some deficiencies. They were mainly caused by:

- unsuitable installation of arrays,
- insufficient attention to battery maintenance,

- lack of voltage disconnect circuits.

It was due to installation errors that arrays were mounted either on the tower or very close to it in such a way, that shadow was cast on the panels.

Normal discharge levels for batteries should not exceed a certain state of charge if a normal life time is expected. Where many deep discharge cycles occurred, for instance as the result of uncorrectly working charge controllers, batteries did not provide a reasonable grade of service for more than 2 or 3 years, instead of 5 to 7. Permanent usage in a hot environment and lack of regular maintenance (electrolyte level) apparently also reduce the normal life time of the battery. Special attention must also paid to the overvoltage setting.

The early MAR systems did not incorporate a low voltage disconnect which assures disconnection of load before damage through deep discharge occurs. As for the solar panels themselves, they are very seldom specifically damaged and did not deteriorate after several years of usage. (Source: document No. 17 of Bibliography).

4.8.5 Aspects of O & M and Quality of Service

Traditionally, rural subscriber access systems in Zimbabwe are largely based on overhead lines which requires considerable costs for manpower and material in the field of O & M. Therefore, great expectations were raised when multi-access radio systems appeared on the market. The first MAR system (SR 100) was commissioned in 1984, and there are currently 7 systems of the SR 100 type installed and 4 awaiting installation.

Although the equipment is supposed to be appropriate for the applications and well suited for the programmes of PTC, technical problems were reported with the MAR systems providing poor reliability of service. Initial indications were that problems are related to design and component deficiencies in the power system (refer to paragraph 4.8.4), and to an underestimation of skills required for installation and maintenance.

As for the lack of inadequate maintenance, transportation services were reported to be a major problem for maintaining the MAR systems. Poor roads have caused frequent breakdown of vehicles and limited access to the equipment. (Source: Document No. 17 in Bibliography).

Within the framework of an overhaul programme, an investigation on recurring problems with SR 100 systems since the time of installation was carried out by the manufacturer, i.e. SR Telecom Inc., Canada. According to the relevant report (Document No. 19 in the Bibliography), deficiencies and faults were found in the following areas: radio equipment, antenna systems, solar power systems.

With regard to equipment, some substantial modifications have been carried out, some of them have already become standard items on stations produced later on, such as active isolators for outstation transmitters (to add additional frequency stability to the transmitted signal), low voltage disconnect circuits and low voltage alarms. Apart from some faulty units in the radio systems, important faults were discovered in the power supply equipment (see paragraph 4.8.4).

In the age of information, party-line systems assigned to several subscribers with important traffic can only satisfy a very basic demand. As a result from increasing need for communication, systems are very often overloaded and congestions cause inconvenience to the users, who also complain about missing non voice services (telex, telefax). - A party-line system is technically viable, if the partners make relatively few calls per day, so that interference and permanent overlapping of desired communication does not occur often.

4.8.6 Economic Impact of Rural Telecommunication

Like in other countries in this survey, studies to evaluate the economic impact of rural telecommunications have not yet been carried out. On the other hand, it may be concluded that rural centers could not be effective, since public services (veterinary, health, education...) and marketing boards (cotton, grain) could not operate effectively because of inadequate means of communications.

4.8.7 Tariffs

Presently, the tariffs applied in urban and rural areas respectively are as follows (1 Zim$ is equivalent to approximately 0.5 US$):

Refundable security deposit, both urban and rural:

Business	Zim$ 250.00
Reidential	Zim$ 50.00

Installation charge:

Urban	Zim$ 52.50
Rural (MAR)	Zim$ 210.00

Monthly rental fee:

Urban	Zim$ 5.15
Rural	Zim$ 4.95

Basic unit fee: Zim$ 0.1215 per unit

4.8.8 Summary

In comparison with other countries of the Region, Zimbabwe started very early to elaborate and carry out integrated rural development

programmes. It has consequently acquired valuable experience with various telecommunication systems for application in the rural areas.

Party-line systems are wide-spread but can only offer a limited capacity of service, since they are based on open wire lines.

Zimbabwe was also among the first African countries to embark on digital multi-access subscriber systems. By doing this, PTC had to face a number of unexpected problems which made the systems in some cases quite unreliable. The problems had their origin in the domain of hardware as well as in the human factor. Experience shows, that modern systems always need adequate maintenance, even if they are considered to be "maintenance free".

Repair of a digital equipment by replacement of a panel is an easy job to do in the technical environment of the developed countries. However, it is bound to become a problem in these remote areas where the rural equipment is supposed to penetrate. The nearest available technician to undertake the repair may be very far away and may not have adequate transport facilities. The quantity of rural systems should not go beyond the capabilities of the technicians.

Consequently, when installing more modern systems, the human factor has to be considered more profoundly. Technicians have to be well trained and equipped with necessary tools and reliable vehicles. The more modern the equipment is in the rural area, the more well trained manpower has to be near by to restore service quickly following equipment failure. This can be facilitated by creating accommodation in these areas.

It is also felt, that a centralized fault reporting system and the subsequent analysis of faults would reduce the risk of failure of complete systems.

To prevent faults resulting from lightning, special attention has to be given to the quality of earthing.

Table 4.8: Rural Telecommunication Systems in Zimbabwe

System	Equipment Type	Manufacturer	Installation	Number	Installed capacity	Subscribers connected	Power Supply	Observation
Small analogue exchange	Strowger			40	11200		Mains with standby	
Party line				15		240	Local batteries	
Electronic party line (EPL)				25		200	do	
Subscriber carrier	SOR 10	STC & GEC						
Subscriber carrier	TD3/M	Telettra						
Multi-access radio	SR100	SRT	1984	7	560	211	Mains for central station, mostly solar for out stations + rep.	
Multi-access radio	IRT1500	TRT	1987 + 1989	1 + 1	1'8 120	90 + -	Mains for central station solar for out stations + repeaters	
Multi-access radio	IRT2000	TRT		1		-	-	Commission scheduled 1990
Small capacity		Nokia		5		27	Mains	One system with concentrator on one channel

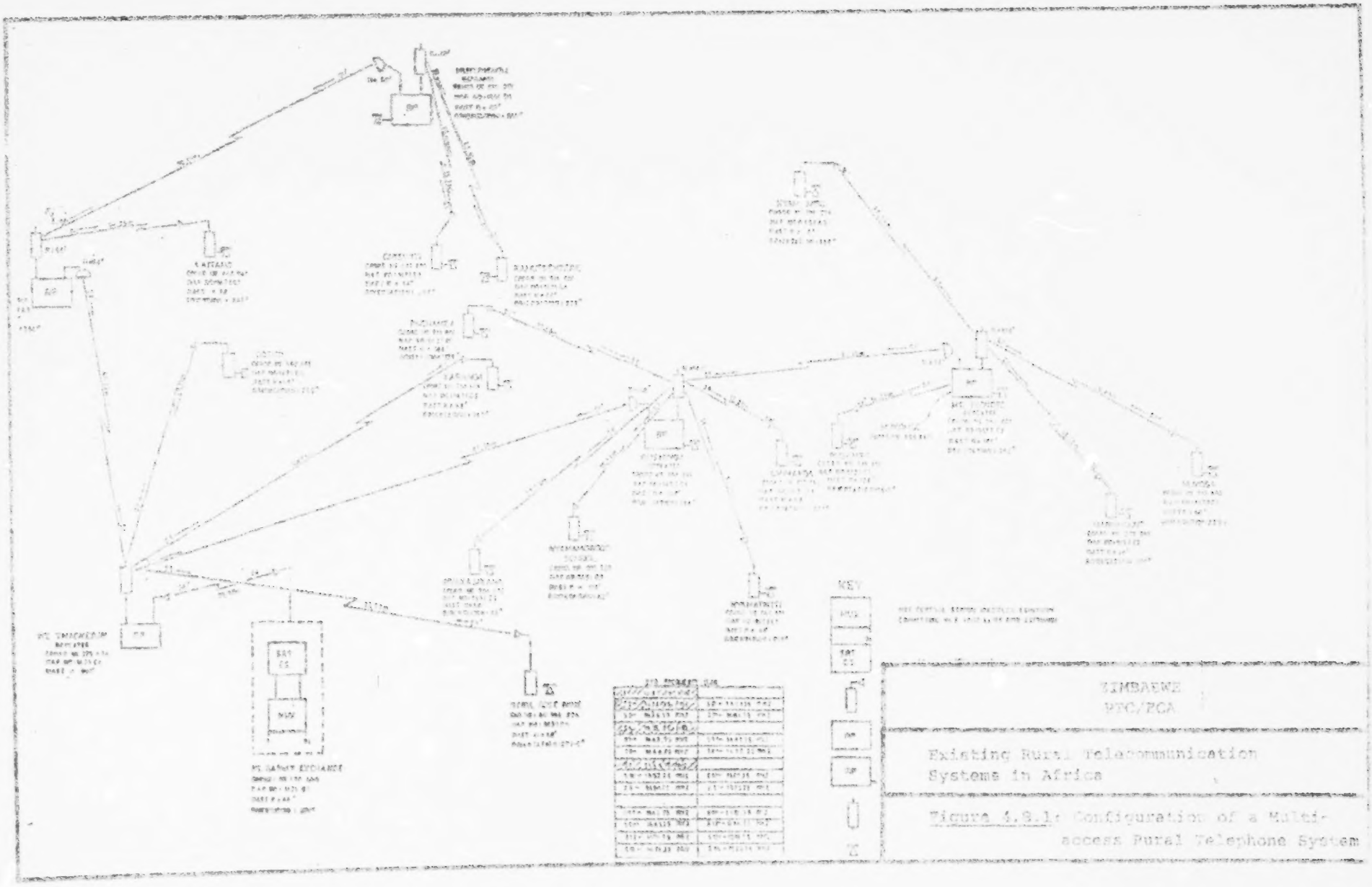


Figure 1.3.1: Configuration of a Multi-access Rural Telephone System

5. Summary of Perceptions

5.1 General situation of rural telelcommunications
5.2 Experience acquired with various systems
5.3 Aspects of power supply
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5.1 General situation of rural telecommunications

The countries visited in connection with this present report have been selected among those having already implemented rural telecommunication services. There are many countries where rural telecommunications are more developed or less or are not available at all. Therefore it has to be made clear, that this document does not reflect the general situation of rural telecommunications in Africa as a whole, but is only giving a synthesis of eight selected countries.

In all eight countries that were visited, considerable efforts have been made to serve remote areas. However none of the countries has already been able to meet the entire rural demand. Either there are areas still not being served at all or the service offered is unsatisfactory.

Given the structural variety of the countries, it is sometimes difficult to make a clear distinction between urban and rural telecommunications. In many cases, there exist recent techniques which are normally used for rural areas, but they are being utilized to serve places having a certain administrative and/or economic importance.
For the purpose of this report the term "rural systems" regards those systems which are conceived to meet a demand that is considerably lower than in big towns. Therefore they need a design which is different from telecommunication systems generally introduced in industrialized countries, where the equipement is also manufactured.

Despite the effort made until now, much more needs to be done in the future. Considerable investment is necessary to meet the most urgent demand, careful planning therefore being a very important basis.

5.2 Experience acquired with various systems

Nearly all modern subscriber access systems mentioned in paragraph 3.3 are being utilized in the eight selected countries. The following techniques have so far been introduced:

(i) Open wire lines with and without carrier systems for trunks and subscribers,

(ii) Manual switchboards,

(iii) Small analogue exchange configurations,

(iv) Small digital exchange configurations,

(v) Analogue concentrators,

(vi) Low capacity digital microwave links and cables with drop/inserts,

(vii) Radio call systems (HF),

(viii) Single-channel radio links,

(ix) Small capacity radio links,

(x) Party-line systems,

(xi) Domestic satellite systems,

(xii) Analogue multi-access radiotelephone systems,

(xiii) Digital multi-access radiotelephone systems.

Open wire lines, with and without carrier systems, are still contributing considerably to rural telecommunications, some of them cover a distance of more than one hundred kilometers (e.g. in Niger). Advantages and disadvantages are very well-known and shall therefore not be discussed in this document. Also in the future they will play their role, especially when subsriber lines have to be distributed within a cluster up to a distance of about 10 kilometers.

In order to utilize the equipment to the end of its life, manual switchboards are still wide-spread. They hardly ever represent new investments, but are generally being "shifted" to remote areas, coming from places which just received modern equipment.

Small analogue exchanges are still being operated in some countries (e.g. Zimbabwe and Malawi) which proves the solidity of electromechanical equipment. These equipment are able to work for about 30 years if it is well maintained and if spare parts are available.

Small digital exchanges coming from two different manufacturers have been implemented since 1986 in two countries among the eight which were visited. In the case of one configuration, some operational problems on the hardware as well as on the software level were reported. However, in the absence of an analytic fault diagnostic for each individual exchange and transmission link, a possible lack of performance of the equipment or of the maintenance procedures could not be concluded.

There are analogue concentrators installed in connection with small analogue and digital microwave links. Only in one country operational problems were reported.

In many countries low capacity microwave links, analogue as well as digital, have been introduced. One administration has purchased a PCM cable. The relays are mostly solar powered. Digital microwave links and cables offer the possibility to extract PCMs. Subscribers are either connected directly or via concentrators or even manual exchanges, where the PCMs are terminating. Small solar powered microwave links are generally working satisfactorily. The PCM cable has been put into service during 1989 only. For this reason the system does not yet allow conclusions concerning O & M.

HF radio call systems are simple and low cost rural communication systems. They are employed where distances are long and the demand is very scattered. In one country power problems, prevent using the stations more than one to three hours daily. However, the requirements are high, especially by government services.

Another solution to meet the demand in remote areas is the utilization of single-channel VHF systems. Quite a number of them (49) are installed in Malawi. The earliest installation there dates back to 1972, and the number has subsequently been increased until 1989. Normally, the links are terminating at PCOs, but in some cases they are used as trunks.

The small capacity radio systems (400 MHz) employed in one network usually provide 4 channels which are used as DELs, however channels may also terminate at a concentrator.

In Zimbabwe party-line systems are wide-spread. They can only offer a limited capacity of service, since they are based on open-wire lines. However, they are still technically viable, if partners make relatively few calls per day, so that interference and permanent overlapping of desired communications does not occur often. To replace obsolete party-line equipment, an electronic system was designed and developed within the Post and Telecommunications Corporation (PTC) of Zimbabwe and which is being manufactured locally.

An alternative technical solution to the HF point-to-point system for the connection of remote stations is the use of a domestic satellite network. Ethiopia and Niger are employing this technology, the latter one already since 1981. The two small earth stations are equipped with 3 channels and also with a TV channel each. Rural earth stations are solar powered, and they work quite satisfactorily.

Ethiopia has purchased five analogue multi-access radio systems (with frequency division). The first system was installed in 1989 and therefore not much experience has been gained.

Digital multi-acces radio systems (with time division) are installed in all eight countries or will be operational very soon. They are coming from three different manufacturers. About 30 systems will be working by the end of 1989 which clearly shows that this technique is very promising and may be applied in many places. Central stations are normally connected to the mains supply, whereas repeater and terminal stations can easily be powered by photovoltaic equipment.

Some countries have made good experience with MAR-systems, however in some areas they work only for a relatively short period. Technical problems have been reported by some countries which were resulting in poor reliability of service. Initial indications are that those problems are related to design and component deficiencies in the power system and to an underestimation of skills required for installation and maintenance. Sometimes there exist problems in the field of maintenance due to insufficient training of technicians and lack of adequate transport facilities. In one case operational problems were originated by a planning error resulting from inadequate frequency management.

Figures 5.1 and 5.2 show MAR stations in Mali and Niger respectively.

5.3 Aspects of power supply

Evidently, power supply is one of the most sensitive elements in the field of rural telecommunication operation. The majority of the countries is taking advantage of a very high insolation and therefore purchase photovoltaic equipment for nearly all modern rural systems. Generally, experiences with solar energy are very good. Some problems were related to insufficient battery capacity and attention to their maintenance. Occasionally solar arrays were unsuitably installed.

In cases where solar energy equipment has been operating for several years, it has been found that batteries did not provide a reasonable grade of service for the expected life time of 5 to 7 years. This may be due to deep discharge cycles, lack of regular maintenance or simply to the fact, that permanent usage in a hot environment may reduce the normal life time of a battery.

As for the solar panels themselves, they are very seldom specifically damaged and did not deteriorate after several years of usage.
The Figures 5.3 and 5.4 show photovoltaic equipment installed in Mali and Niger respectively.

5.4 Benefits from rural services

In the absence of profound studies on the economic impact of rural telecommunications it is convenient to point out that the majority of the investments made in the past is integrated into other development projects where they are contributing to their profitability and efficiency.
In some specific cases, however, subscribers could be interrogated and they confirmed that important savings were being made by utilizing the telephone in comparison with costs for travelling and other disadvantages if the phone was not available.

The economic impact of rural telecommunications may also be assessed by the amount of revenues coming from PCOs and subscribers. In many places, the revenues are important. There exists a large suppressed demand from people able to use the telephone facilities offered by a PCO. The number of

individuals having some coins in their pockets is much higher than of those who can afford the installation and monthly rental fees.
Where lines are installed in tourist sites, the utilization is very high. On the other hand, some development projects could not even exist without telecommunication facilities.

Finally, the penetration of telecommunications into the rural environment has noticeably improved the administrative methods as well as the personal security of its population. In some areas government authorities are the principal users of the services.

Figure 5.1: Yagi antenna for HAR terminal station in Niamey (Office du Niger)

Figure 5.2: Maintenance activities at a HAR terminal station in Niger (Office du N)

Figure 5.7: Solar panels and rectifier/battery for NOR terminal station in Mali (Office du Niger)

Figure 5.8: Solar panels (mounted on cover for battery box) and battery for IAR terminal station in Niger (Parc du W)

6. CONCLUSIONS AND RECOMMENDATIONS

6.1 Conclusions
6.2 Recommendations

6.1 Conclusions

(i) In all eight countries which have been visited, many efforts have been made to meet the rural demand. However, high investment costs did not allow them to construct rural telecommunication networks that cover the whole area.

(ii) Conventional techniques (electromechanical exchanges, manual switchboards, ...) are still being operational. Their efficiency is sometimes very low, due to lack of spare parts.

(iii) Open-wire lines still do form an important part of rural networks. The maintenance costs are rather high, part of them being necessary for transport facilities.

(iv) Considerable experience has been gained with modern technology. But some administrations had to face a number of unexpected problems which made the systems in some cases unreliable. The problems had their origin in the domain of hardware as well as in the human factor.

(v) Repair of a digital equipment by replacement of a panel is an easy job to do in the technical environment of the developed countries. However, it is bound to become a problem in those remote areas where the rural equipment is supposed to penetrate. The nearest available technician to undertake the repair may be very far away and may not have adequate transport facilities. The quantity of the equipment should not go beyond the capabilities of the technicians.

(vi) Robust equipment may turn out to be fragile when placed into an inadequate environment. There are sometimes fault delays of several months due to insufficient training of technicians and also to the phenomenon that they attach less importance to telecommunications in rural areas than if they were placed in urban areas.

(vii) An important factor in achieving acceptable equipment availability is the mean time to restore service following equipment failure. In turn, that time is dependent largely on the efficiency of the maintenance organization and the level and distribution of spare replacement units held in stock.

(viii) The facilities and operating characteristics of digital multi-access radiotelephone systems match or exceed those available to any other subscriber in the network. Their connection to the public telecommunication network normally presents no problem neither to traditional analogue exchanges nor to the currently favoured digital exchanges. However, the planning and design procedures are somehow complex.

(ix) The use of communication satellites while entirely feasible, is limited because of the present very high cost of terminals and continuing foreign exchange burden for rental of satellite facility. It is, however, for some countries the last resort in the professional telecommunications world, when other media prove to be impracticable for technical reasons.

(x) Experience shows, that modern systems always need adequate maintenance, even if they are considered to be "maintenance free".

(xi) Although modern installations for rural telephony do not create particular problems with regard to operation, there are considerable damages caused in the periphery by lightning, particularly originated by bad earthing.

6.2 Recommendations

(i) When installing modern systems, the human factor has to be considered more profoundly. Technicians have to be well trained and equipped with the necessary tools and reliable vehicles. The more modern the equipment is in the rural area, the more well trained manpower has to be near by to restore service quickly following equipment failure. This can be facilitated by creating staff accommodation in these areas.

(ii) Before further expanding rural telecommunications, the administrations should improve the structure of operation and maintenance (customer service).

(iii) Maintenance technicians for modern radio systems must have a general appreciation of radio propagation, and be well prepared in the areas of antennas, transmission lines, radio equipment and multiplex, solar arrays and batteries.

(iv) Maintenance shops or repair depots should exist locally to alliviate the turn around delay and reduce the demand for foreign exchange.

(v) Centralized fault reporting systems and the subsequent analysis of faults would reduce the risk of failure of complete systems.

(vi) To avoid perturbations by strange frequencies it will be necessary to consult neighbouring countries on the utilization of frequencies, especially in boundary regions, as and when the number of MAR-systems will increase.

(vii) By improving the administration's manpower resources, important part of planning and installation might be carried out by its own staff. This will considerably reduce the costs of projects in comparison with those which are executed on a turnkey basis.

(viii) Given the findings of this survey, it is timely that manufacturing facilities be considered for local production of a range of telecommunications equipment suitable for rural areas.

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